TALKING ELECTRONICS®

HELPS YOU UNDERSTAND ELECTRONICS

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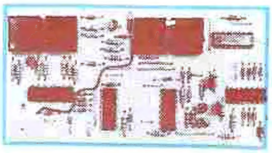
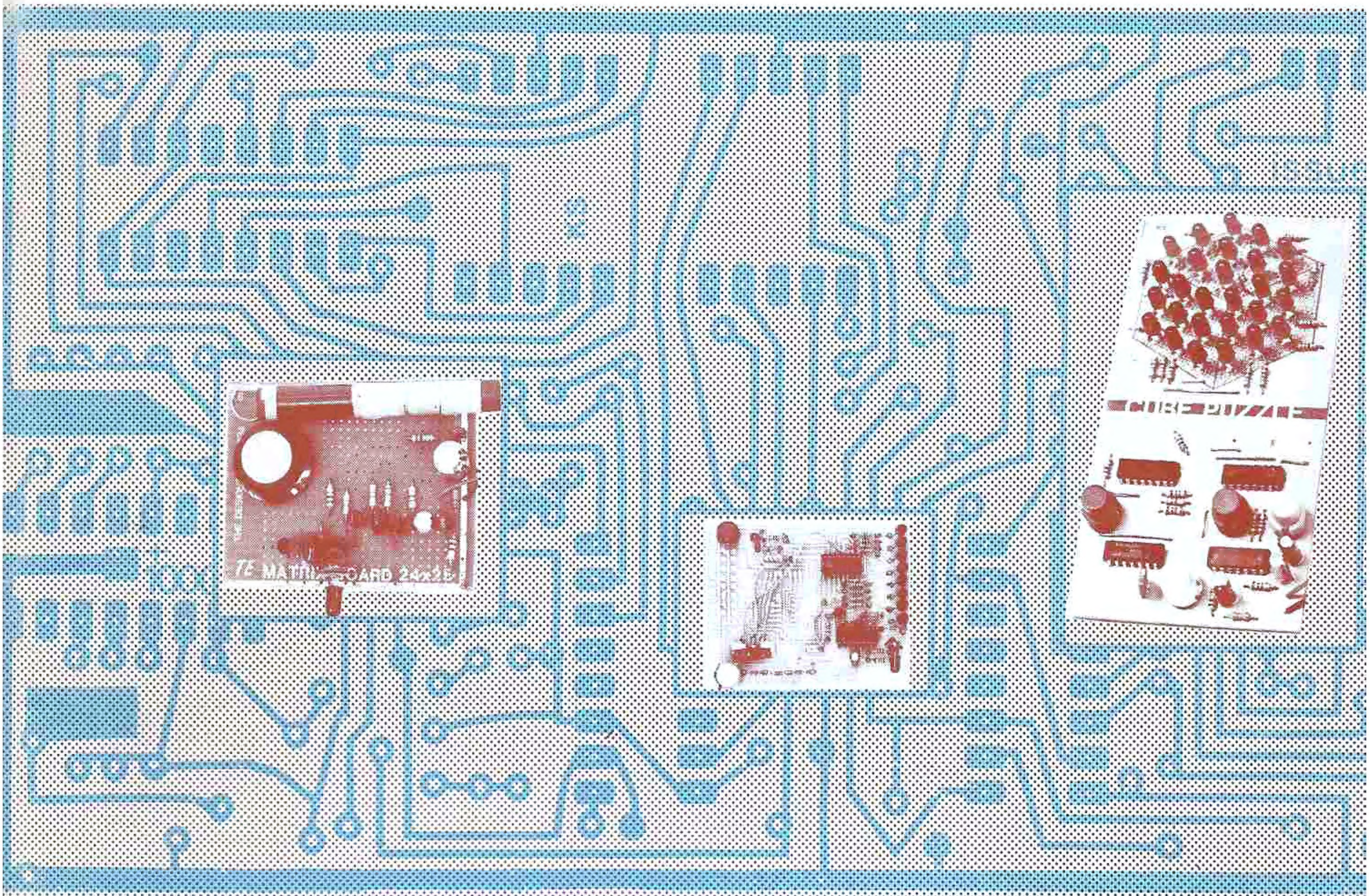
DIGITAL CLOCK



Issue No 8.

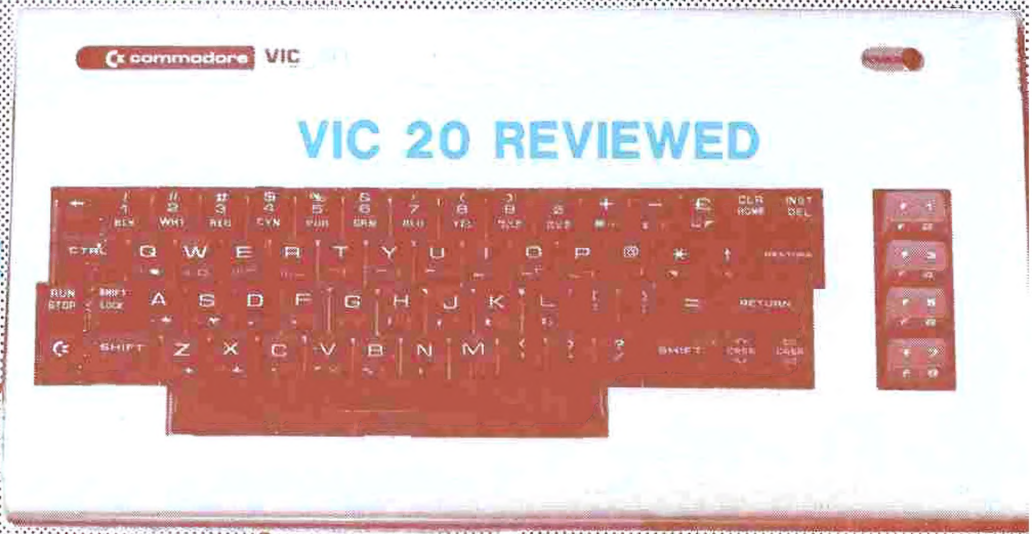


CUBE PUZZLE

IC RADIO

PROGRAMMABLE LIGHT CHASER

VIC 20 REVIEWED



TALKING ELECTRONICS

Editorial... Vol. 1. No. 8.

The layout of magazines has always amazed me. Have you noticed how they present all the best material in the first half and as you pass the half-way mark, the quality deterioriates to a miserable conclusion.

Take an opposite. A movie film. Imagine if a film maker started with a grand opening and as the movie progressed, the story-line became weaker and weaker and weaker. It doesn't happen because the film maker is intent on selling the product to scrutineering eyes. He has to sell to a very critical distributor as well as take the brunt of criticism from film critics.

This isn't the case with magazines. In fact it is quite the opposite. The realities are quite disturbing. If you thumb through any of a dozen magazines, you will see what I mean. The colour is concentrated towards the front, the editorial matter is heavy at the commencement and the quality of the paper is superb at the beginning. Everything seems to deterioriate as the page numbers increase. Have you ever thought "Why is this so?" Have you ever contemplated the main factor which sells a magazine?

If you think it's the editorial or the main articles, you will be wrong. The main drawcard is the advertisements. The brightly coloured eye-catching trivia of the ad agencies. And the proof is easy to demonstrate.

A magazine containing 60% advertising will sell faster and in greater quantities than a spin-off consisting solely of editorial matter. And this is most disappointing.

Subconsciously we tend to gravitate towards the promotional material more than looking for substance in the text.

If we take the specific case of electronic magazines, this situation has allowed the technical sections of many magazines to become complacent to the extent that they can present less material per issue than ten years ago. All in an era when electronics is expanding five times faster than a decade ago!

One magazine in England has endevoured to reverse this trend. Edited by Ray Marston, it has successfully increased its number of pages in the seventh issue and is currently providing the best ratio of technical material to advertising. On the home front, I think we are providing a fair example of what should be done for the hobbyist. I do not want to include any more advertising than absolutely necessary to provide a back-up for the constuction of the projects. Too often these advertisements date a magazine and within a month or so, the January specials are stale. Even our first issue still has the same demand for projects as it did a year ago. Basic electronics and theory do not date. It will still be true and current five or ten years from now. Let's hope we are still here to demonstrate it.

Colin Mitchell.

TECHNICAL

Ken Stone

ARTWORK

Paul O'Callaghan

ENQUIRIES

10 Minute queries will be answered on 584 2386

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INDEX

Rosemary Socic of Sandringham Technical School didn't solve our CUBE PUZZLE but hasn't given up yet.

TE Clock

Ideal for your workshop or beside your bed, this illuminated clock can be read by day or night. It will help you run to time.

Our cover feature is a clock. A simple every-day timepiece. Something we think very little about. Most of us have a clock in at least two rooms of the house and at least one of these will be digital. If not, you will be particularly interested in our project. If you already have a digital clock, you will appreciate the advantage of an illuminated dial.

One hundred years ago, the purchase of a time-piece was a great decision. Miniature clocks and watches were enormously expensive and necessitated careful decision as to the most suitable model and the relative costs.

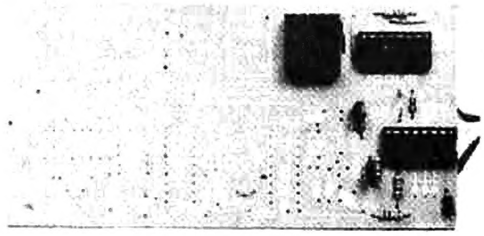
Clocks have always been an item of great beauty. If you have ever wandered through the clock section of a museum you will appreciate the aesthetic designs which have been incorporated into the face and even the workings of many clocks and watches.

This is the only mechanical product I can recall where the workings have been specifically designed to be ornate as well as being fully functional.

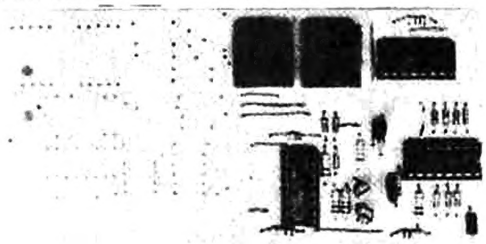
From the beginning of time, man has strived to produce a more accurate time keeper. From the simple time-candle, to the atomic clock, we have seen the introduction of one improvement after another. As you are possibly aware, the biggest threat to accurate time keeping has always been temperature. The variation between hot and cold expands and contracts all materials such that a pendulum will increase in length on a hot day with the effect that it will swing at a slower rate. Some form of temperature compensation is required which will alter the distributed mass of the pendulum and keep its centre of gravity constant. Once this was achieved, the next major breakthrough was the balance wheel. This enabled pendulums to be incorporated into pocket watches where the pendulum needed to be compact and placed in any position and still function. Again, temperature compensation had to be included in the form of two bonded metals on the rim to expand or contract the arms of the balance wheel. Static and dynamic balancing was also an essential part of accuracy and for a tiny set of screws was placed on the rim of the balance wheel. Needle point bearings and jewels were added to reduce friction and for 30 years the Swiss engineers had the watch market sewn up.

The clock is constructed in 4 stages. Each stage adds a display to the board. After completing each stage with its associated driving components, the clock is tested. This will reduce the chance of a mistake and make troubleshooting very easy. . . .if required.

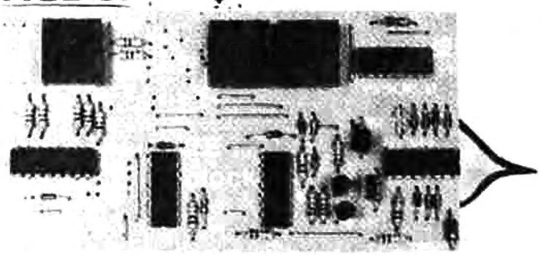
STAGE 1:



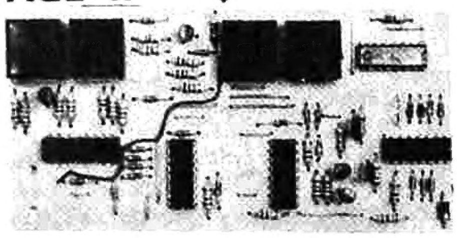
STAGE 2:



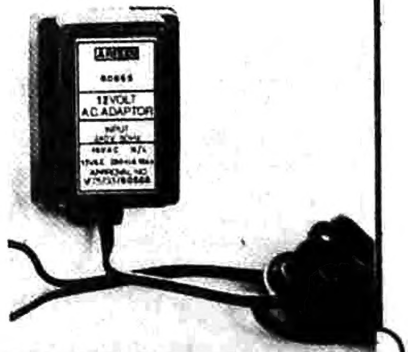
STAGE 3:



STAGE 4:



An AC plug pack of 100 - 300mA rating powers the clock. Don't use a DC plug pack as we need the AC to trigger the 4040 counter chip. The ripple from the DC plug pack would not be sufficient.



A partial threat came with the introduction of electronic watches using a tuning fork principle and an enormous chain of gears to divide down the vibration of the resonating arm.

It was not until the introduction of digital electronics and its miniaturization due to the US space program, that the wind-up watch market crashed.

Every-one likes new and potentially more-accurate devices. The consumer abandoned his old watch for one of these new electronic wonders. Initially they were LED displays and needed a switch to illuminate the dial. This worked well for a while but if your required to know the time more than once per day, the battery life was severely limited.

The introduction LCD displays and a one year battery life cured that. You could now get a watch having an accuracy of .1 second per month, for less than a wind-up style. Additionally the watch would run for about a year on one set of batteries and had an extra feature of day, date and alarm. Some even boasted dual time zones and stop-watch facilities, all at a price below that of 10 years ago.

It's no wonder digital watches took off.

For a construction project, there is one obstacle to producing a digital watch or clock. Most of the chips used in these products are designed especially for a partcular function and no technical knowledge is to be gained by soldering a single chip into a circuit.

On the other hand, if we produce a clock circuit using a purely digital approach, the number of chips required make construction very costly.

So some form of compromise has to be made. The readout can still be digital but the method by which some of the digital stages operate will have to be simplified with a few tricks. By bending the rules a little, we can produce a digital clock with as few as 5 chips. And this is what we have done. We have used transistors for some of the operations.

Before constructing this project, you must have completed at least three other projects from TE or other magazines. There are two main reasons for this.

1. It will ensure only those capable of constructing a project of this complexity, do so
2. It will spread out the construction of the clock over a longer period of time to allow everone to buy the components. This is important as some of the IC's are in relatively short supply.

It does not matter which three projects you have constructed however the inclusion of the LOGIC DESIGNER will be an advantage since it will be used in the testing of each stage.

USING CD 4033's

If you experience difficulty obtaining CD 4026 IC's, a replacement in the form of CD 4033 can be used.

The only modification to the board is at pin 14. It must be taken LOW to prevent the display showing a figure 8 at all times. Pin 14 is the LAMP TEST pin and when it is taken HIGH, it presents an output on all segments to test if they are all operating.

The other difference between the chips is pin 3. The 4033 provides ripple blanking at pin 3 which can be used to suppress unwanted zero's at the beginning of decimal numbers. With suppression, a number such as 00.05 would be shown as 0.05. This line is held HIGH for normal operation as is the display enable of the 4026. Therefore no modification is needed to the PC board.

In place of the Display Enable out, pin 4 is Ripple Blanking out. AS the display enable out is not connected in the project, no modification is needed at this pin.

PARTS LIST

1 - 220R
7 - 470R
1 - 2k7
5 - 10k
6 - 100k
1 - 330k
1 - 470k
2 - 1M

2 - 10n greencap
1 - 1000mfd 25v electro

1 - 1N 4001 diode
22 - 1N 914 diode

3 - BC 547 transistors
1 - BC 557 transistor

4 - FND 500 display

2 - CD 4026 (or CD 4033 with mod)
1 - CD 4040 binary counter IC
1 - CD 4511 display driver IC
1 - CD 4518 dual BCD counter IC

tinned copper wire
Plug pack 9v AC 200mA
TE CLOCK PC BOARD

BEFORE ASSEMBLY

Before you add any components to the board, it must be inspected. This isn't a 5 second glance-over. It will take at least 5 minutes to fully inspect both sides of the board and remedy any slight imperfections. You will need a sharp knife and a drill which is capable of accepting a fine twist bit such as a number 60 drill or a .85mm, .9mm .95mm or 1mm bit.

Refer to the layout pattern for the correct position of the copper tracks. Make sure none of the tracks touch each other or even come near to each other. If two tracks short out,you will damage one of the chips, especially if it is a display driver. Cut between the tracks with the knife so that the gap is enlarged.

Next you should check for any undrilled holes. Every pad should be drilled and even one or two holes are required on the bus rails. If you need to drill a hole, make sure the land is free of excess solder to prevent the drill wandering off centre. Use only a sharp drill as a blunt one will lift the land off the board. If this happens, don't worry, when you are assembling the project, the component lead can be bent over and soldered to the remaining part of the track.

Finally inspect the overlay for any missed printing.
This inspection should be done at least twice. It is so easy to miss a fault when you are not familiar with a situation.

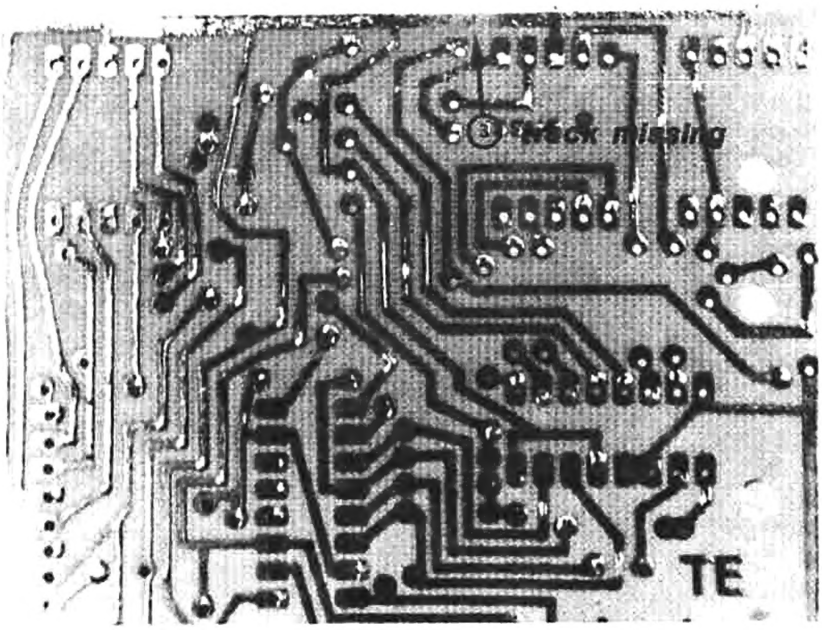
The photos show three common faults on PC boards:
1.Undrilled holes.
2.Touching lands.
3.Tracks missing.

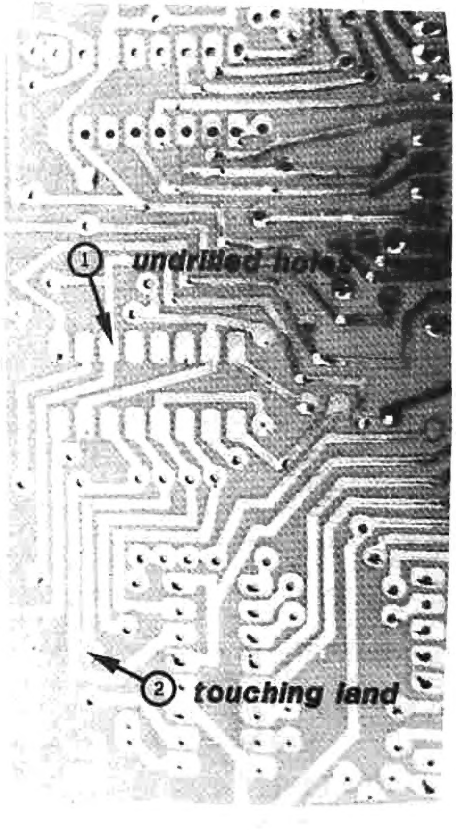
SOLDERING

Look at your soldering iron. Is it a temperature controlled Weller or a Scope TC 60? Is it a Dick Smith Special or an Ellistronics cheapie or an Altronics $10 special? This is about the only range of soldering irons I will accept for the construction of our projects. If you are using greater than 35 watts or an instant heat iron such as Scope or Birko or Pronto, they can be thrown out immediately. We don't want our projects ruined with a plummers soldering iron or a frizzling hot instant iron. They absolutely butcher the boards and damage the parts in the process. You cannot possibly expect the project to work properly after plastering it together with a cumbersome tool.

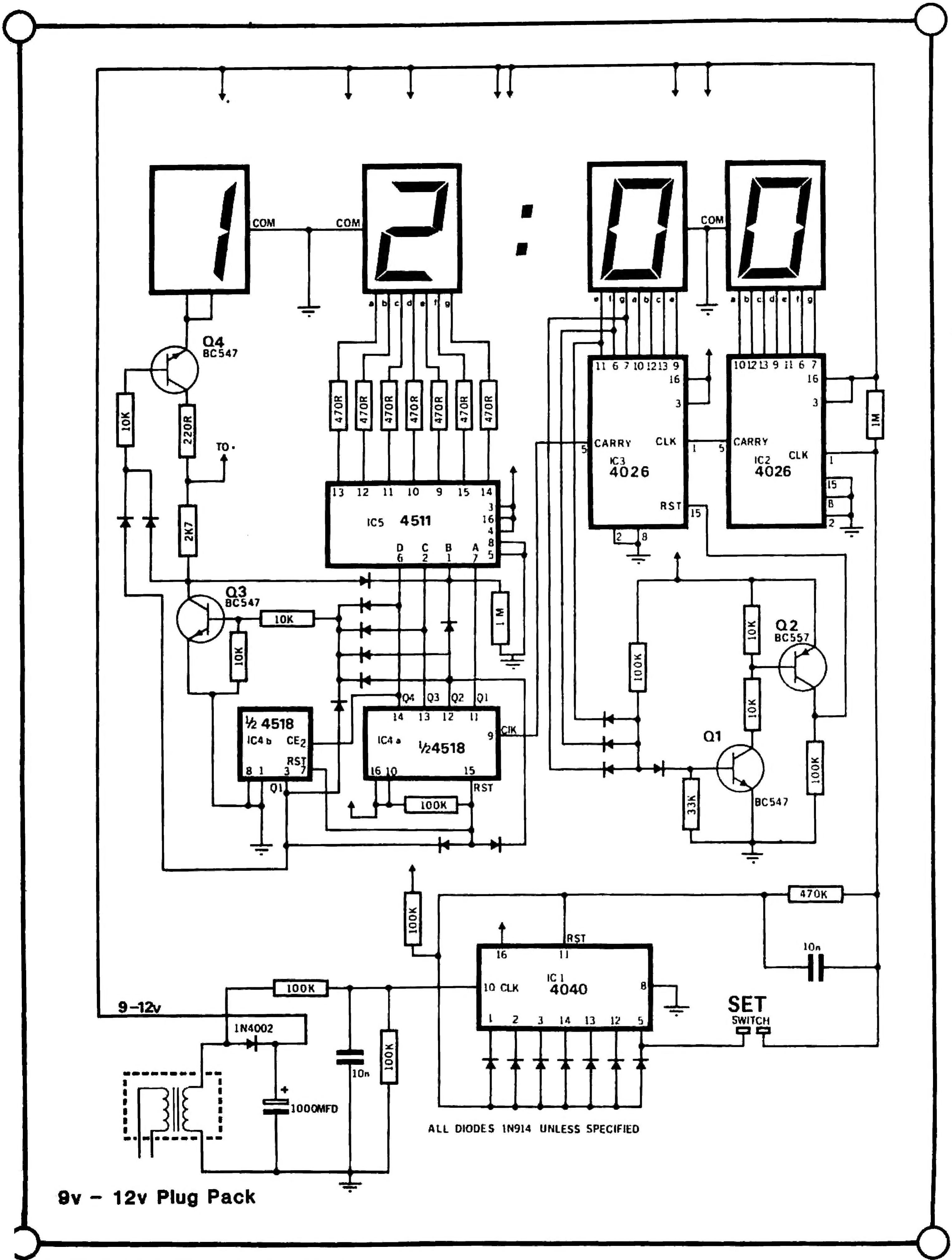
The second point of concern is the type of solder you are using. We use only .71mm resin cored solder and with no additional skill from you, the constructor, the projects looks 100% better than using thick awkward solder. The solder joints come up cleaner, brighter and very little resin is left behind. I think you will be quite surprised at the improvement when using fine solder, and especially so for the clock.
1mm solder is also available in handy rolls and will perform an equally satisfactory job.

So please, please don't make a mess and then turn around and blame TE for a bad design because we know the clock circuit works and will be a valuable time piece in your workshop.





Three common PC faults.


COM
COM
COM
Q4
BC547
10K
220R
TO
2K7
470R
470R
470R
470R
470R
470R
470R
IC5 4511
13 12 11 10 9 15 14
3
16
4
8
5
D C B A
6 2 1 7
1M
Q3
BC547
10K
10K
½ 4518
IC4 b
CE2
RST
8 1 3 7
Q1
Q4 Q3 Q2 Q1
14 13 12 11
IC4 a
½4518
9
CLK
16 10 15
RST
100K
e f g a b c e
a b c d e f g
11 6 7 10 12 13 9
16
3
CARRY
CLK
5
1
IC3
4026
RST
15
2 8
10 12 13 9 11 6 7
16
3
CARRY
5
IC2
CLK
1
4026
15
8
2
1M
Q2
BC557
10K
10K
100K
Q1
BC547
33K
100K
100K
470K
10n
RST
16 11
10 CLK
IC 1
4040
8
1 2 3 14 13 12 5
SET
SWITCH
9–12v
100K
1N4002
+
1000MFD
10n
100K
ALL DIODES 1N914 UNLESS SPECIFIED
9v – 12v Plug Pack

HOW THE CIRCUIT WORKS

The clock circuit derives its accuracy by dividing the 50 cycles per second mains frequency into a digital readout. The SEC maintains a prescribed number of cycles per year and this is a fairly accurate method of driving a clock. After all, most AC clocks use a synchronous motor to drive the hands and they have been accepted as being accurate for most businesses and factories.

The input to the clock appears at the lower left hand corner in the form of a power transformer. The secondary should be about 9 to 15v AC at 100mA to 300mA. The AC waveform is passed through a voltage dividing network made up of two 100k resistors and the signal appears at the input of IC1, a CD 4040 binary counter IC. This counter has been decoded with 7 diodes to count to 3,000 and reset. These diodes form an AND gate and when all the 7 outputs are HIGH, the reset line will go HIGH due to the 100k pull-up resistor.

This occurs once every minute and this pulse is also passed to IC2, a CD 4026 decade divider and display driver chip. The 470k and 1M resistors provide a slight positive voltage on the input of the CD 4026 so that the chip will clock on each minute pulse. The 4026 is a display driver and each clock pulse will appear on the FND 500 display as MINUTES. The output of the chip is pin 5 and this is connected to the input of a second CD 4026. As you are fully aware, a clock displays 0 to 59 minutes and the second display is required to count 0 to 5.

To produce this count and reset sequence, we have diode detected segments e, f and g of the display. These three segments are characteristic to the figure 6 and when these lines go HIGH, the AND gate is allowed to go HIGH via the 100k pull-up resistor to turn on the BC 547 transistor. This in turn activates the inverter transistor, a BC 557, to provide the reset pin with a HIGH. The reason for the double inversion is due to the low voltage appearing at the output of the drive lines. This voltage would not be sufficient to reset the chip. The diode in the base line of the BC 547 transistor eliminates the slight voltage present at the anode ends of the AND gate, which would have the effect of turning on the BC 547 transistor. The output of IC3 passes to the clock pin of a BCD counter, a CD 4518 dual BCD counter IC.

This next stage uses a little magic. As you know, a clock is required to count to 12. If you study the counting sequence for the hours display, you will see it is required to display: 1,2,3,4,5,6,7,8,9,0,1,2,1,2,3,4,5,etc In the middle of this sequence we have an un-inviting 1,2,1,2, sequence. To produce this we have had to produce a few little tricks. The 4518 counter has BCD outputs. These have been diode gated into a BC 547 transistor so that when any of the 5 diode lines is HIGH, the transistor is turned on and does not feed IC 5 via the diode to pin 1.

IC4a counts normally from 1 to 8 when, at this stage, Q4 receives a HIGH. This HIGH is passed to the seond half of the chip which has its clock pin connected to earth and the clock enable pin connected to Q4 of IC 4a. By wiring the counter in this manner, it will increment on the falling edge of the waveform.

This situation occurs when the counter IC 4a passes from 9 to 0 and the resulting figures on the display show 10. The next incomming clock pulse produces an 11 on the display and every thing up to now is quite normal. When the next clock pulse arrives at counter 'a' , pin 12 goes HIGH and this resets the counter to zero via the diode between pins 15 and 12. This action can take place due to the pull up resistor providing a HIGH, because pin 3 is also HIGH and the diode between pins 3 and 15 will allow this rise to occur. Both counters are now set to zero and this removes the HIGHs from the 5 diode OR gate so that the BC 547 transistor is switched off. Its collector voltage rises due to the presence of the 2k7 resistor and this artificially puts a 12 on the screen via the diode into pin 1 of the 4518. It will also turn on the top BC 547 by supplying voltage into the base circuit via the diode and 10k resistor.

The next clock pulse to arrive will turn off this arrangement and display a 1 on the screen....exactly what we want.

A fast-forward feature is provided on the clock for setting the time. This is shown in the lower right hand corner. The SET SWITCH is really two pieces of wire which are touched with your finger to allow the 3Hz signal appearing at pin 5 of the CD 4040 to pass to the first CD 4026. This produces the slow clocking feature. If you touch the two wires very lightly, you will place the 4026 in its intermediate zone and this will produce a very rapid clocking of the displays, similar to fast-forward. By using this feature, you can set any time on the clock in a matter of moments.

The power supply for the clock is provided by a diode and 1000mfd electrolytic. This electro is mounted under the board to keep the board neat.

The only other 4 components which need mentioning are resistors. The two 10k base resistors on the BC 547 provide a load for the OR gate so that the voltage drops to zero when all lines are LOW.

The 1M resistor on pin 1 of the 4511 decks the input pin since it has two OR gate diodes feeding the pin and this will create a floating situation which must be tied low.

The 220R resistor feeding the hours digit is a voltage dropper for the '1' segments.

BEFORE ASSEMBLY

Before starting construction, sort out all the components in an orderly layout. Keep the integrated circuits wrapped up but make sure you have the correct types. Check for the letters FND 500 on the displays or look into the red diffusing screen and locate the decimal point. Pick out the BC 557 and the 1N 4001 diode. Tick off all the resistors against the parts list and keep the pen handy as you will need it to tick off each stage as you complete it.

(   ) Layout all the components neatly with all the resistors facing the one direction.

( ) Check that all the components are in the kit, or if you have purchased them separately, make sure that all in front of you.

(   ) Arrange for an AC power supply of about 12v AC to be available. The best choice is an AC plug pack as it is completely insulated. A small power transformer such as 2155 or 2851, properly insulated in a plastic box with power lead attached and earthed, will be quite suitable.

(   ) Collect up all the necessary tools, such as side cutters, pliers, small screwdriver, soldering iron, solder, iron stand.

(   ) Check the PC board for undrilled holes, blocked holes, broken lands or touching lands. The Clock board is possibly the best PC we have produced and should not have any faults. But when you produce many thousands of PC boards, one or two faults will inveriably creap in. Make sure you have a fairly good idea of where the parts are required to go.

(   ) Decide if you are going to use sockets for this project. This is always a very wise precaution. We haven't used them of supplied

precaution. We haven't used them or supplied them in the kits as it adds to the cost and tends to make the completed project a little more bulky. If you have any doubts about your ability at soldering you should use sockets for the four chips.

CONSTRUCTION

The construcion of the clock is separated into 4 stages. Each stage adds one display to the readout. Upon completion of each stage, the circuit is thoroughly tested. The power is applied and the clock is allowed to run.

This is the first stage:

Refer to the photo and the overlay for the position of the parts for this stage.

( ) Fit the 1N 4001 diode. The bar or line on the diode goes "down".

(   ) Fit the IC socket for the 4040 so that the cutout on the socket (indicating pin 1) is near the edge of the board.

( ) Fit the three 100k resistors. Push them onto the board and splay their leads outwards so that they stay in position while soldering.

(   ) Fit the 470k resistor.

( ) Fit the two 10n capacitors. Push them close to the board and solder their leads.

(   ) Make the SET SWTICH by creating a loop with tinned copper wire 2cm high. Solder it in position, then cut the top of the loop to create a small gap.

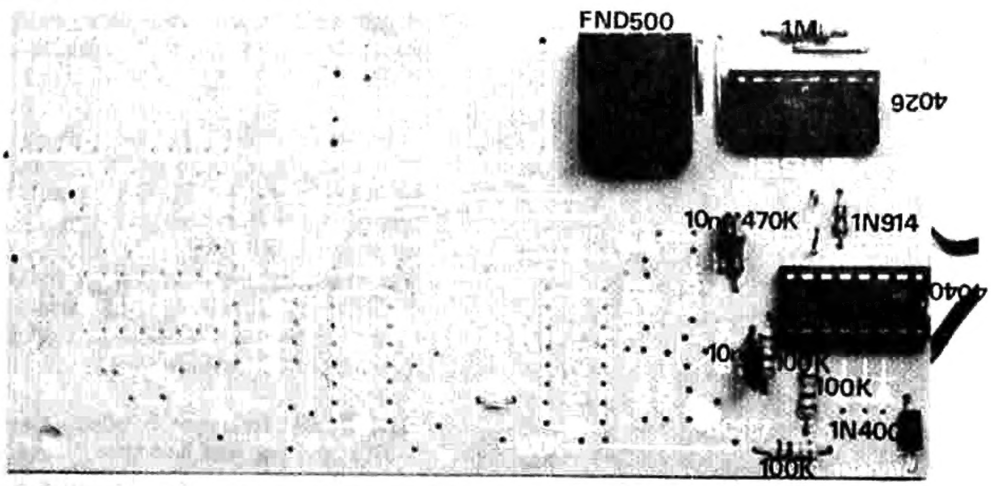
(   ) Fit the Q4 diode, a 1N 914 diode. This will give a 3Hz clock pulse to the first 7-segment display.

( ) Fit the top 4026 IC socket. This chip has pin 1 near the KS symbol.

(   ) Fit the top 1M resistor.

(   ) Fit the link next to the 1M resistor.

(   ) Fit the 2 links between the minutes FND 500 and the 4026 socket.



( ) Fit the minutes FND 500, making sure the decimal point covers the dot on the layout.

( ) Fit a short link near the centre of the board towards the bottom, to supply the positive rail voltage.

( ) Fit the 1000mfd electrolytic. This is mounted on the underside of the board. Locate the square solder land beneath the 4040 socket for the positive lead and the thick land beneath the row of gating diodes for the negative lead. No holes are needed for the electrolytic. The leads solder onto the copper tracks.

( ) Fit the 4040 IC with pin 1 near the edge of the board. The numbers on the chip may be upside-down.

( ) Fit the 4026 with pin 1 near the KS sign. Do not go by the numbers on the chip, look for the indent at the end of the IC for pin 1 identification.

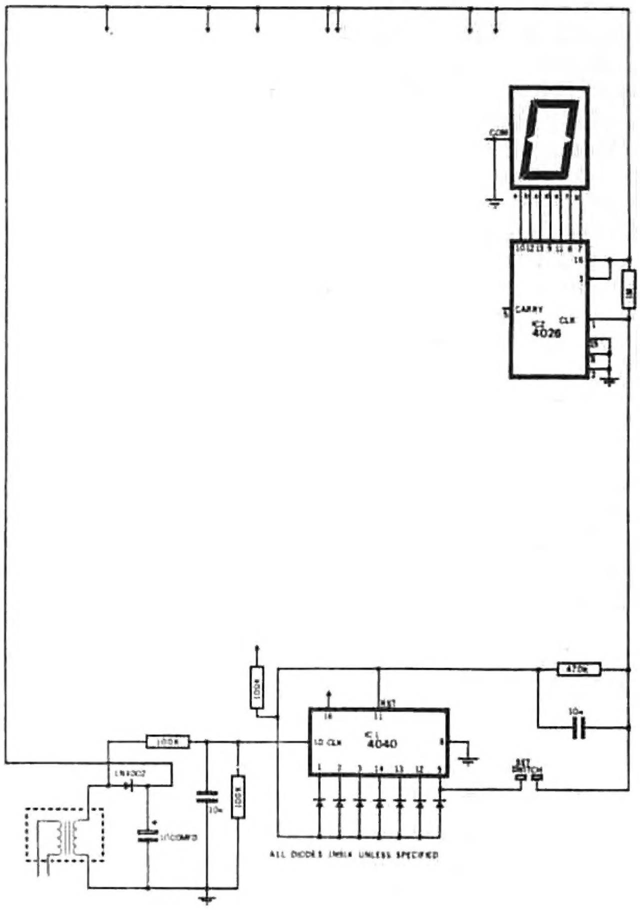
( ) Solder either lead of the AC plug pack to the large land beneath the row of diodes and the other lead to the earth rail, which is beneath the 1N 914 diode.

( ) Switch on. The display will clock at approximately 3 numbers per second.

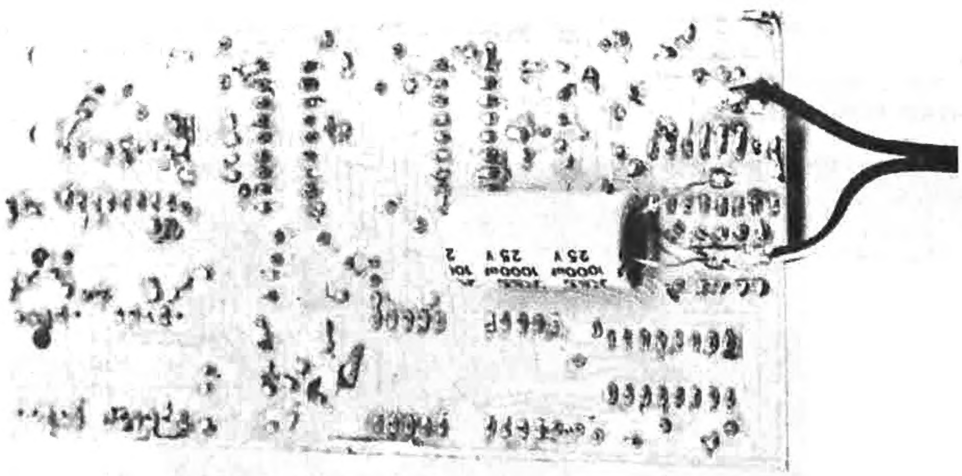
( ) Once the minutes display clocks at 3Hz, you add the remaining gating diodes to create a MINUTES readout.

( ) Add the remaining 6 gating diodes, type 1N 914.

( ) Switch the clock on and wait for the display to change. Start timing the clock with your watch. Let the clock run for a few minutes and see if the display changes at minute intervals.



THE CIRCUIT DIAGRAM FOR THE FIRST STAGE



THE ELECTROLYTIC IS SOLDERED TO THE UNDERSIDE OF THE BOARD AS SHOWN IN THE PHOTO.

QUESTION:
You have two clocks. One does not work at all. The other loses about 1 minute per day. Which clock is the more accurate?

ANSWER:
The non-working clock. It tells the correct time twice per day. The other clock is only accurate every two years!

IF IT DOESN'T WORK:

Connect the AC terminals of the LOGIC DESIGNER to the AC input of the clock in the following manner: Connect the ground terminal of the LOGIC DESIGNER to the earth of the clock and the top AC terminal of the Logic Designer connects to the anode of the 1N 4002 diode on the clock.

Connect a jumper to the clock pin of the 4024 on the Logic Designer via a 100k "stopper" resistor to be used as a test lead.

If the clock does not light up, check the link near the centre of the board for continuity. You can use one of the buffer transistors to check this. Check the voltage at pin 16 of the CD 4026.

( ) Check the 50Hz signal at the anode of the 1N 4002 diode with the clock input of the 4024. This binary counter should fill very quickly at 50Hz.

( ) Check for 50Hz at the clock input of the 4040 (pin10) with the input lead of the 4024 counter.

( ) Check for 25Hz at pin 10 with the test lead of the 4024.

( ) For the first section of the project, the 4040 produces a 3Hz signal via output Q4. Detect this signal on the 4024 binary counter.

( ) Check the anode end of the gating diode with a buffer lead. The 4024 may not detect this pulse as it does not rise high enough to clock the counter.
With the last two steps you have proven that the signal emerges from the 4040 and passes through the gating diode.

( ) Check the 3Hz signal at pin 1 of the CD 4026. The output pins 6,7,9,10,11,12,and 13 can be detected with a buffer lead. If the display fails to light up, check the soldering to all the display pins, the insertion of the display and the earth line.

STAGE 2:

This stage will create the minutes display reading 10's, 20's, 30's, 40's and 50's. The display is required to reset after 5 and not sho the figure 6. To achieve this, we need a couple of transistors and some biasing components.
After completing this stage, half the board will be constructed.

( ) Fit the carry-out link at the top of the board, near the letters KS (if this has not alrady been done).

( ) Fit the lower 4026 socket. Make sure the pin 1 identification faces downwards.

( ) Fit the 4 1N 914 diodes.

( ) Fit 2 x 100k, 2 x 10k, 1 x 330k resistors.

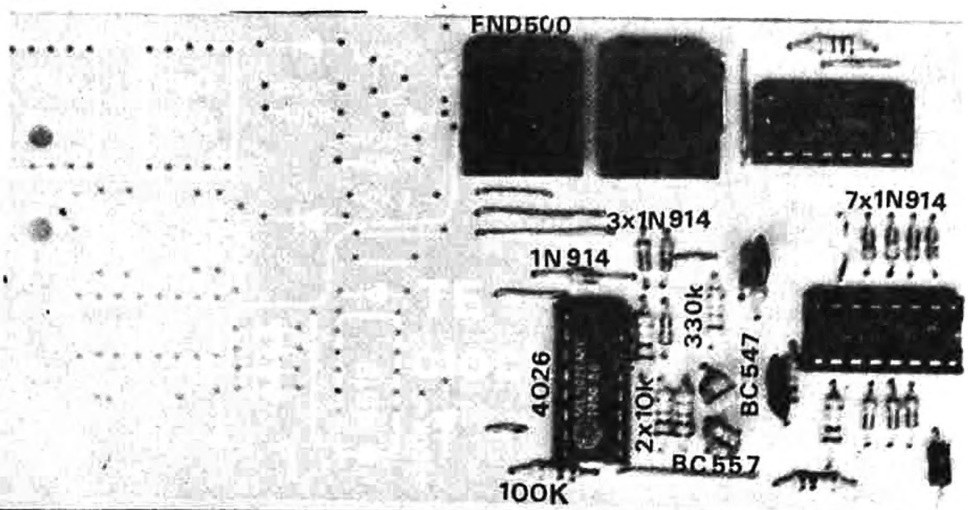
( ) Fit 6 links to this section of the board as shown.

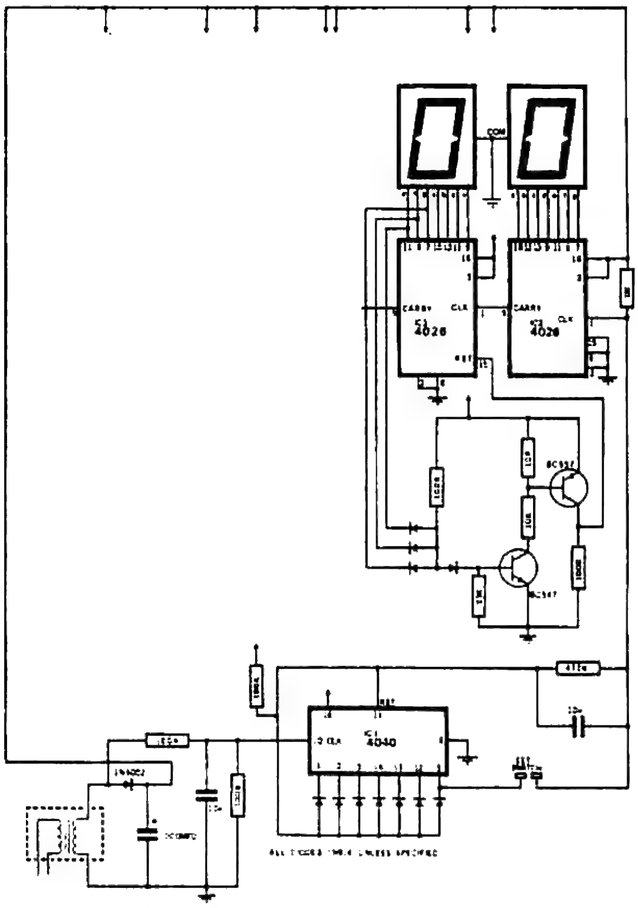
( ) Fit the BC 547 transistor.

( ) Fit the BC 557 transistor.

( ) Fit the FND 500 display.

( ) Insert the CD 4026 IC into the socket so that pin 1 is near the edge of the board.
Check all soldering for shorts between connections and make sure no leads are unsoldered.
Connect the power and join the SET SWTICH wire together with a clip. The minutes display will count to 59 then reset.





THE CIRCUIT DIAGRAM FOR THE SECOND STAGE

IF IT DOESN'T WORK:

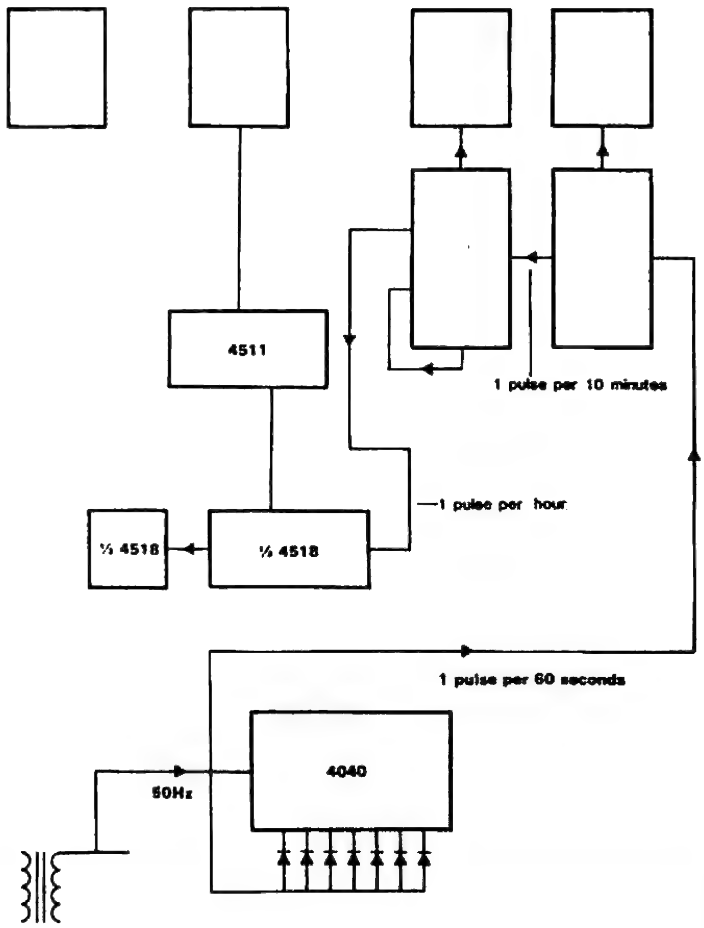
If the display is passing 5 and showing 6,7,8,9, the reset circuit is not operating. Firstly check the BC 547 and BC 557 transistors for correct insertion. At rest, the collector of the BC 547 should be very nearly rail voltage and zero voltage on the collector of the BC 557.

Check the operation of this circuit by powering the clock and take a 10k jumper lead from the positive rail to pin 15 of IC 3. If this resets the chip, take the 10k resistor from earth to the base of the BC 557. Next take a 10k resistor from rail to the base of the BC 547. These three tests should reset the chip.
To check the AND gate, remove one end of the three diodes and switch the clock on. If the display does not reset, the base diode is open or the 100k resistor is faulty.

If the display does not advance past zero, the reset line is remaining on. Remove the BC 557 and operate the clock. If the display remain on zero, check the 100k resistor in the reset line. Take pin 15 to earth with a jumper. The 4026 should now count. If not, the chip is faulty.

Place a jumper from the anode of the diodes to earth. If the display counts, a leakage voltage is present at this point. The base diode is designed to remove it and may be faulty. Replacve the base diode. If the display fails to change, check the voltage on the 100k resistor. It should be about .5v. If it is 1v or higher, check the cathode voltage of the three diodes. It should be less than .5v for a non-lit segment. You can put two diodes in series in the base line to remove the voltage from the AND gate. Short the 33k resistor with a jumper lead. If the display fails to change, replace the BC 547 and BC 557.

SIGNAL PATH



STAGE 3:

This section will add parts to drive the hours display. (It will not produce the complete 1 - 12 readout).

(   ) Fit the seven 470R dropper resistors.

( ) Fit the two IC sockets. Make sure you know which end identifies pin 1.

( ) Fit the 1N 914 diode at the bottom left hand corner of the board, below the 4511 IC.

(   ) Fit the 100k near the 4518 IC holder.

(   ) Fit the 1N 914 diode next to this resistor.

(   ) Fit the FND 500 display.

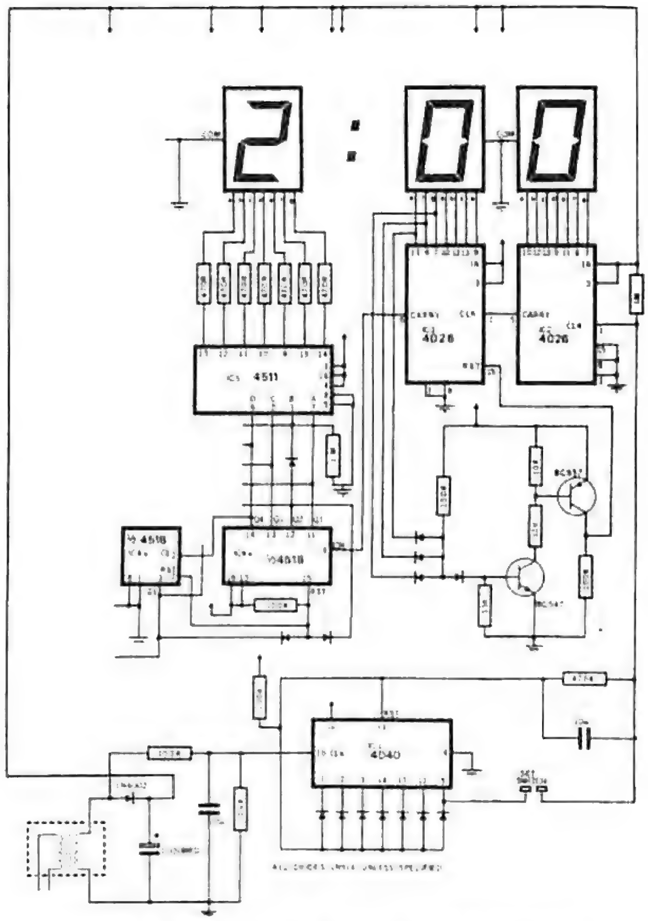
(   ) Fit the 5 jumper links as shown.

(   ) Fit the 4518 IC with pin 1 downwards as shown.

(   ) Fit the 4511 with pin 1 near the 4 large staple holes.

( ) Check all the solder connection and see that all parts have been inserted as shown on the photograph.

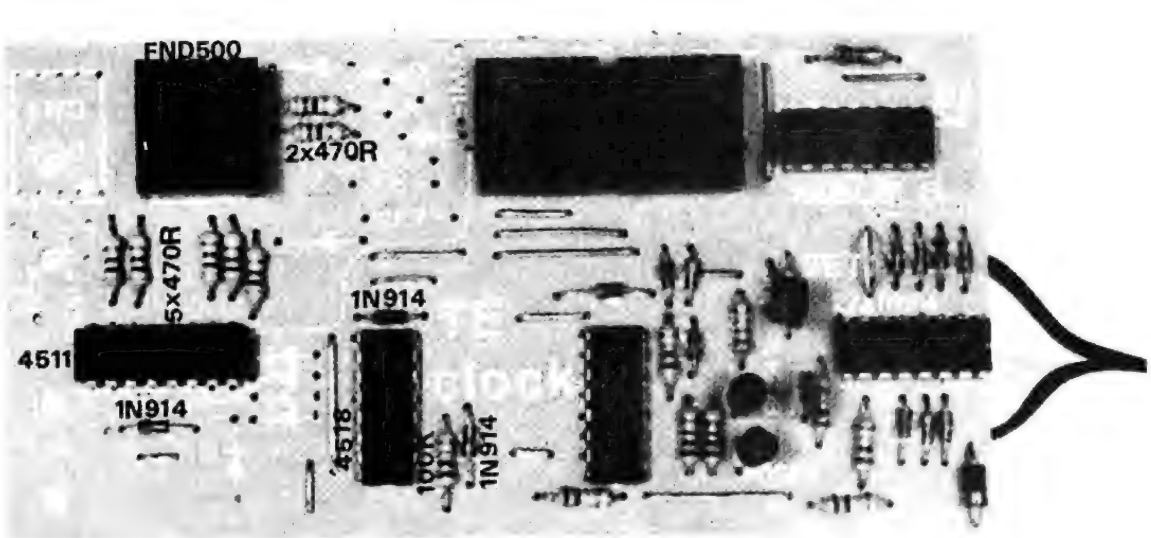
(   ) Switch on the supply and note the illumination of the three displays.
They may not come on with all segments lit as the chips should be reset or clocked through one complete cycle. Allow the clock to fast forward by placing your finger very lightly on the SET SWITCH. The readout should clock 0 - 9 and this will indicate that all segments are operating.



THE CIRCUIT DIAGRAM FOR THE THIRD STAGE.

IF IT DOESN'T WORK:

If one segment fails to light up, check the 470R resistor for a dry joint or the display for a faulty segment. You can check each segment via a jumber lead and 1k resistor.
If the display fails to clock, check the voltage on pin 15 of IC 4. Deck pin 15 and re-test.



STAGE 4:

Stage 4 adds the special gating required to obtain a 1-12 readout.

(   ) Fit the long jumper wire running from between the displays to the bottom left hand corner of the board.

(   ) Fit the eight 1N 914 diodes.

( ) Fit six resistors: 1 x 220R, 3 x 10k, 1 x 2k7, 1 x 1M.

(   ) Fit the FND 500 display.

(   ) Fit 2 x BC 547 transistors.

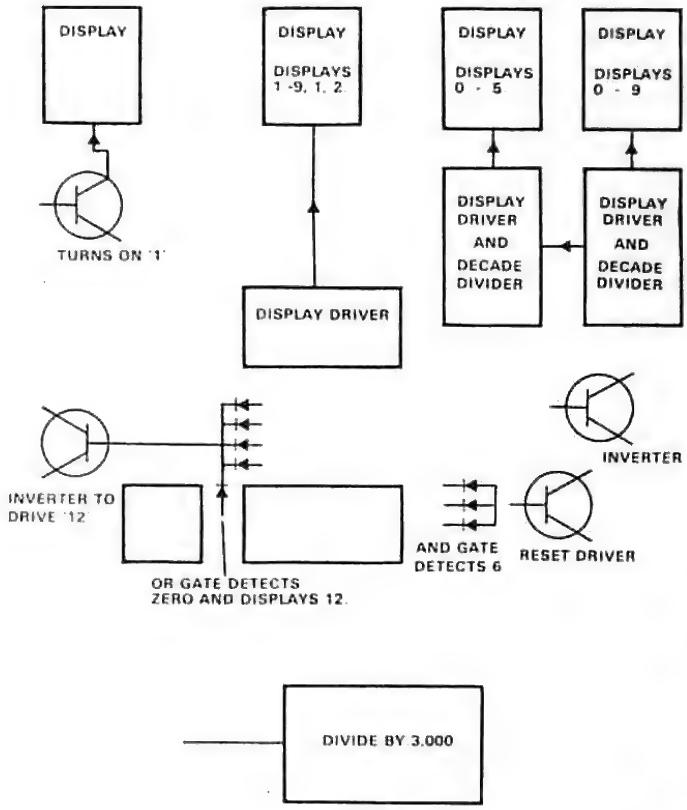
FINAL TESTING

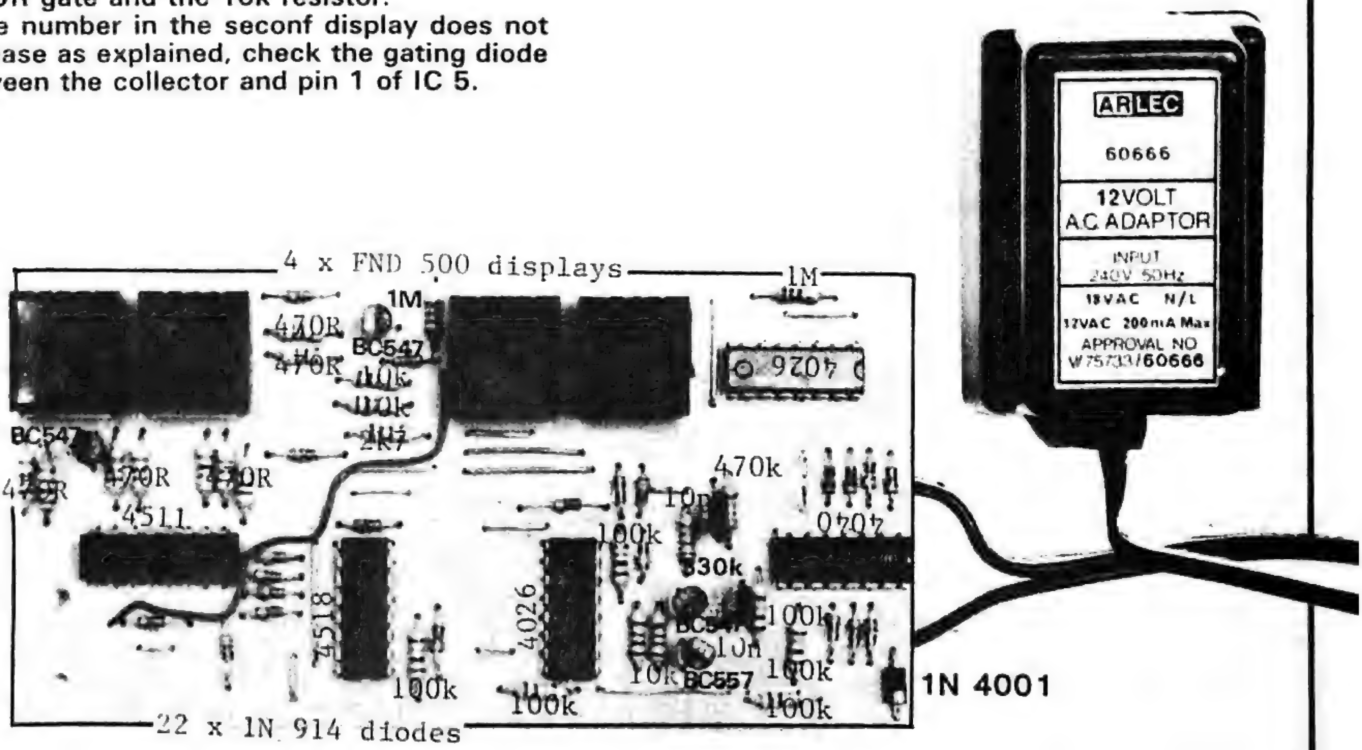
TESING Q3 and Q4.

Transistor Q3 is designed to force a 12 on the screen when the two counters are recording 00. By decking the base voltage with a jumper lead, a '1' will appear on the first display and the number in the second display will be increased by two if it is a 1,4,5,7,8, or 9. Otherwise numbers such as 2, 3 and 6 will not alter.

If a '1' does not appear on the first display, check transistor Q4, by placing a 10k resistor on jumber leads to positive and touch the base lead. If a '1' does not appear, replace the transistor. If it does appear, check the diode on the OR gate and the 10k resistor.
If the number in the seconf display does not increase as explained, check the gating diode between the collector and pin 1 of IC 5.

THE FUNCTION OF EACH ITEM





THE COMPLETED CLOCK

SOME COMMON DIODE FAULTS:

FAULT: The display does not show 10 or 11. It jumps from 9 to 12.

REMEDY: The diode between pins 12 and 15 is open or faulty.

FAULT: The display jumps from 1 to 12 to 1 to 12.

REMEDY: Diode between pin 3 and 7 is open or faulty.

FAULT: Display shows 9, 12, 11, 12, 1, 2, 3, etc.

REMEDY: Diode from pin 3 to AND GATE faulty or open.

FAULT: Display shows 1,2,3,4,5,6,7,1?,9,10, 11,12 1 etc.

REMEDY: Diode from pin 14 open of faulty.

FAULT: Display shows: 7,8,9,10,11,12,1,2,3 16,5,6,7,8 etc.

REMEDY: Diode from pin 13 faulty or open.

FAULT: Display shows 1,12,3,4,5,6,7,8,9, 010,11,12,1 etc.

REMEDY: Diode from pin 12 faulty or open.

FAULT: Display shows 12,13,2,3,4,5,6,7,8,9, 10,11,1 etc.

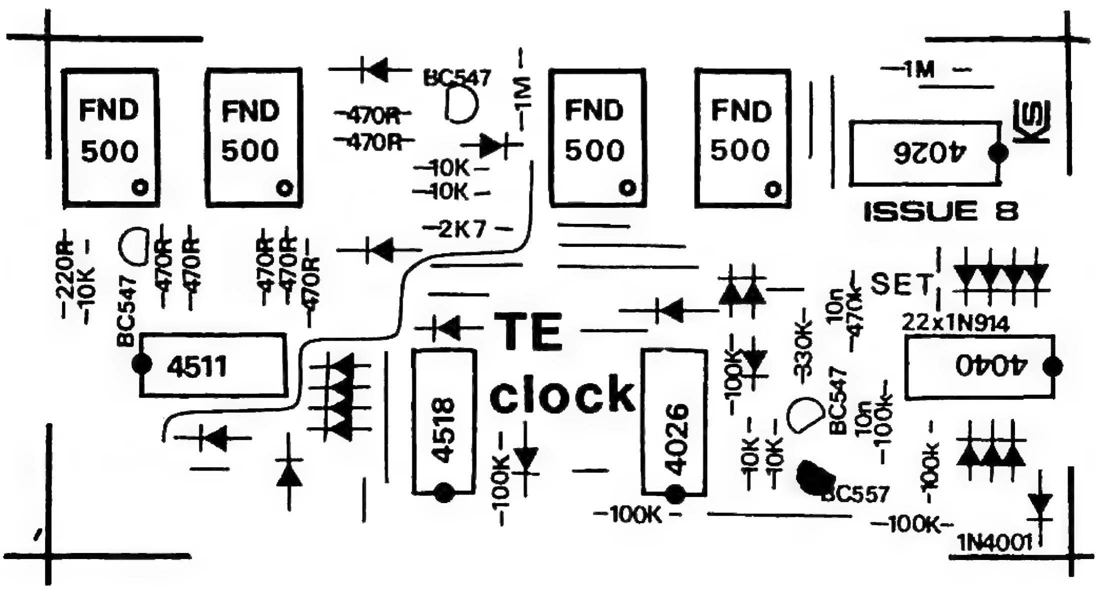
REMEDY: Diode from pin 11 faulty or open.

HELP, IT DOESN'T WORK!

We have covered some interesting and usual faults. It could be taht your unit develops other faults due to a combination of two or more components failing at the same time. I do not want to scare you, but to fix your own project will be the best education you can get.

Approach the problem logically and try to narrow the fault down to a small part of the circuit. You will need a multimeter and either a Logic Probe or the LOGIC DESIGNER. Quite seriously, I hope your project does contain a small fault. After you find the fault and fix it, you will say "Gee, that TE clock project is really great". Take it from me, I know; I learnt the hard way. No-one showed me how to fix faults, and once you solve it yourself, you NEVER forget.
We receive a few letters every wek from readers who solve a problem in one of their projects and the feelig of achievement is really great. They can't begin to thank us enough.

If however, youhave really tried to find the fault and it eludes you, we will offer a repair service for the clock at a fixed fee. To be acceptable for repair, your project must be completed on the PC board enclosed with the magazine and must contain sockets for the IC's. The soldering must be nice and neat and all parts must be as per the overlay.
You do not have to send the power transformer but the project must be well-packed in a jiffy bag with plenty of styreme foam packing to protect the board.
Mark your jiffy bag:
Clock project,
Box 486,
Cheltenham, 3192.
Enclose your name and address and the $8.00 fee.



DESIGNING WITH TRANSISTORS

This is the second installment in a multi-part discussion on transistors. The first section dealt biasing a transistor wired in the COMMON EMITTER MODE. This section deals with the transistor as a SWITCH.

Transistors can be connected in three different configurations: COMMON EMITTER, COMMON BASE and COMMON COLLECTOR. The common emitter arrangement is the most versatile as it produces the maximum power gain. Some of the other feature which make it so suitable for many of our applications include: medium input impedance, medium output impedance, ability to operate on a wide range of supply voltages, ability to be stabilized via feedback to reduce distortion and the use of non-critical biasing components.

Unfortunately there is one enormous problem with electronics. It is a non-linear medium. Most of our requirements for amplifiers etc are linear and audio and electronics really don't go together at all.

Fortunately we will not be dealing with the transistor as an amplifier in this section and our discussion will highlight upon a sector where electronics excels.
We will be dealing with the transistor as a switch.

For many readers, using a transistor as a switch will be a new consideration. We will still be using the transistor in a common emitter configuration but the actual operation of the circuit has some distinguishing features which have to be recognised if you wish to identify a switching circuit.

In a normal common emitter stage, the transistor must be biased to operate somewhere in the middle of its range. This requires the base voltage to be set so that the transistor is slightly turned on. This will enable the transistor to be driven equally by positive and negative waveforms. You can see this for yourself by noting the quiescent or standing voltage on the collector and then measuring the maximum and minimum voltages on the collector terminal. If the collector operates in the range 2v to 7v for a 9v supply, the transistor is said to be operating in a suitable range or "MID-RANGE".

The main requirement for a common emitter stage in an amplifier is to give an accurate reproduction of the incomming waveform. If this is achieved, the stage is of some use. The actual gain of the stage is of little concern as additional stages will produce the necessary overall gain for the amplifier. The only function of each stage is to produce an accurate amplification without introducing distortion. Distortion is produced when the transistor is driven beyond its linear range, such as when the collector voltage comes near the supply voltage or drops below 2v. Distortion-free response is very important in an amplifier since the output is feeding a speaker and we want the sound to be as clean as possible.

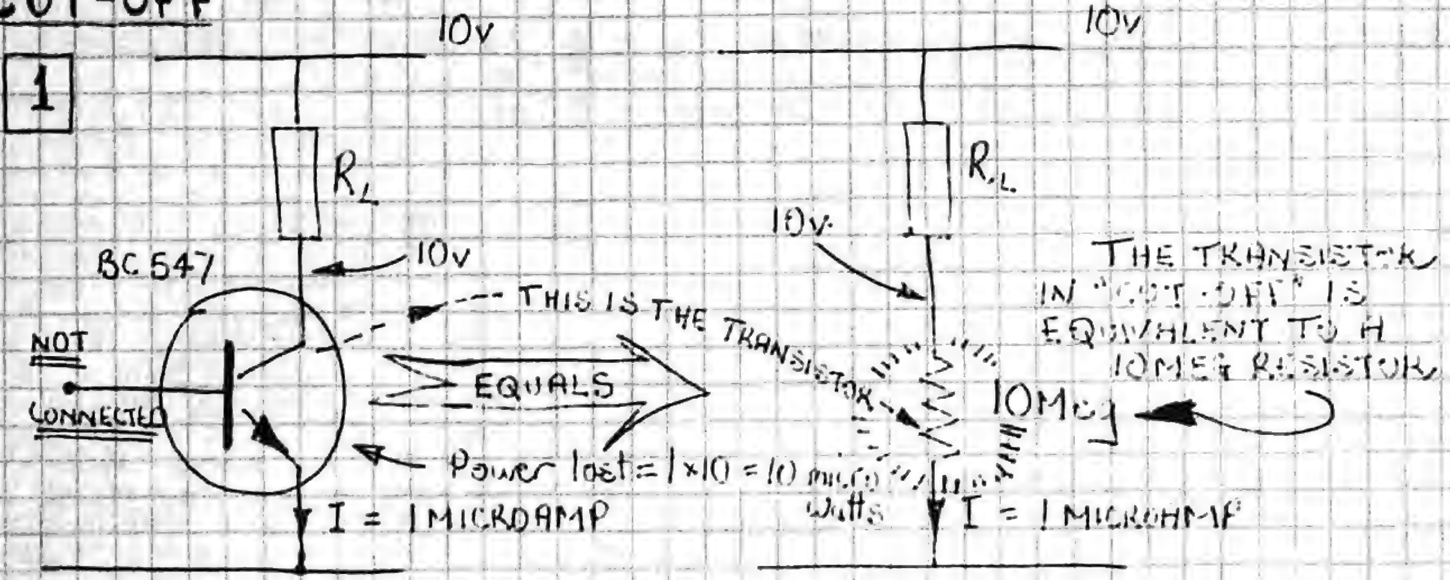
But suppose we wish to operate a relay in place of the speaker?

Here, the same number of amplifying stages would be needed, but the output stage would differ. In place of an amplifying output stage, we would need a switching stage.
This is the requirement of a VOX. A VOX is a voice operated switch. You may have seen one in opertion on a tape recorder. When you begin to speak into the microphone, the tape recorder operates. When you finish speaking, the tape stops. This conserves tape and keeps your hands free for other operations. This arrangement can also be seen on walkie-talkies or telephone answering machines.

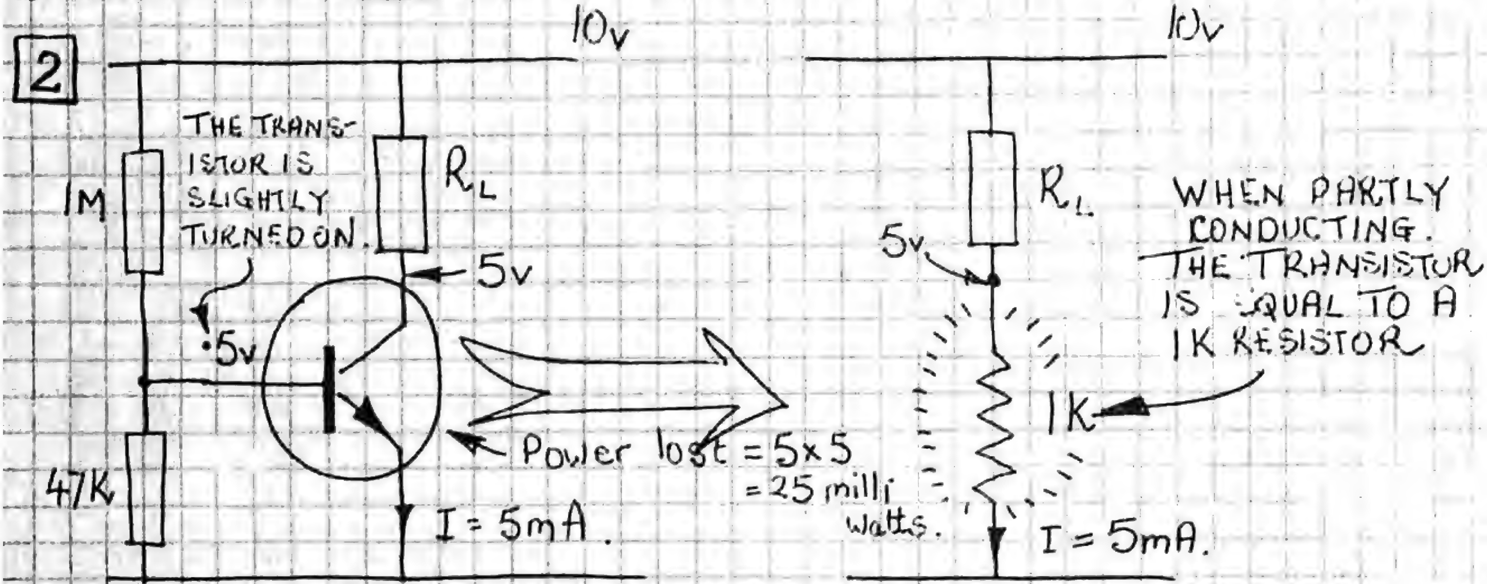
The circuit for a VOX would be a number of amplifying stages feeding a switching stage. This would then be directly coupled to a relay. Obviously it would not matter how much audio distortion is produced by the amplifier as there is no speaker in the output. The section we are mainly concerned with is the output stage. To operate a speaker, this stage is a power amp, one which is turned on and off according to the input waveform. But a relay doesn't want to be pulsed according to the sounds being amplified. It needs to be turned on at the commencement of the signal and kept on until the signal stops.

To achieve this, the driving stage is not designed as an amplifier but as a switch. There are many applications where a switching stage is needed. A VOX is only one example and is possible the simplest and best to use at this stage.
Surprisingly, this type of circuit is almost identical to a normal amplifier. By looking at the two circuits you could hardly tell the difference.

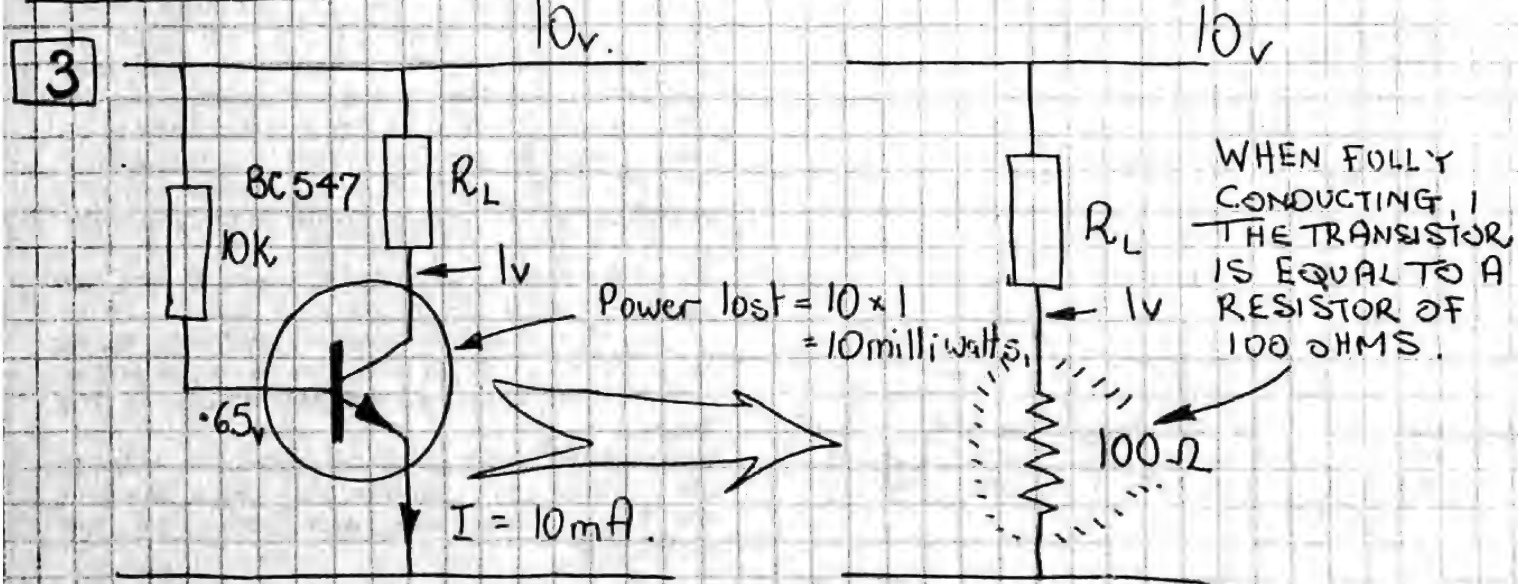
CUT-OFF



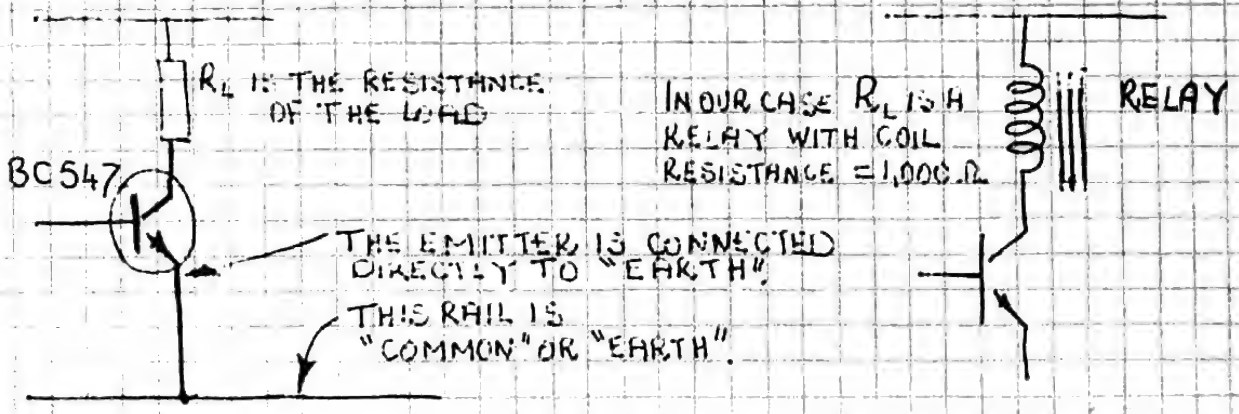
PARTLY CONDUCTING



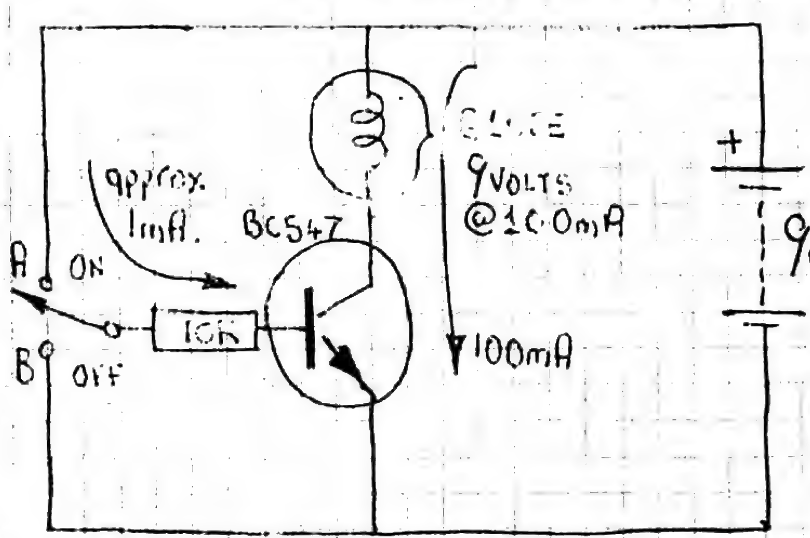
SATURATED



The TRANSISTOR as a SWITCH

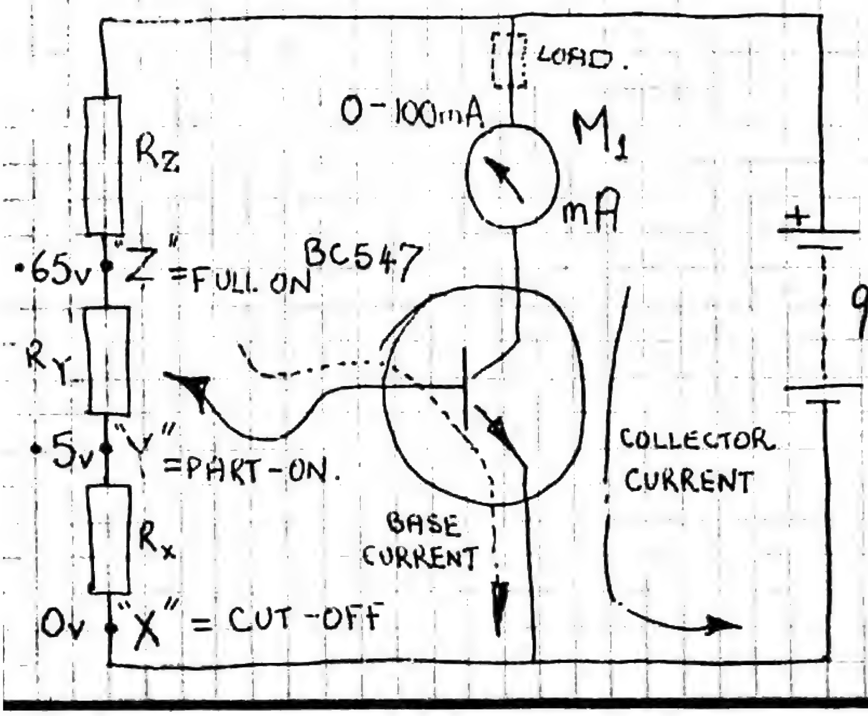


A BC 547 CONNECTED IN COMMON EMITTER MODE.



WHEN THE SWITCH IS IN POSITION "A", 1mA WILL FLOW IN THE BASE CIRCUIT AND THIS WILL TURN THE TRANSISTOR ON. THE COLLECTOR-EMITTER CIRCUIT WILL PASS 100mA TO ILLUMINATE THE LAMP. THIS SHOWS THE TRANSISTOR HAS AN AMPLIFICATION OR GAIN OF "100 TIMES". & SINCE IT HAS ONLY TWO STATES "ON" AND "OFF", IT IS ACTING AS A SWITCH.

A BC547 AS A SWITCH.



THIS CIRCUIT SHOWS HOW AN NPN TRANSISTOR "TURNS ON" AS THE BASE VOLTAGE INCREASES.

RESISTORS R_X R_Y & R_Z ARE ADJUSTED TO GIVE ·5v AT Y & ·65v AT Z.

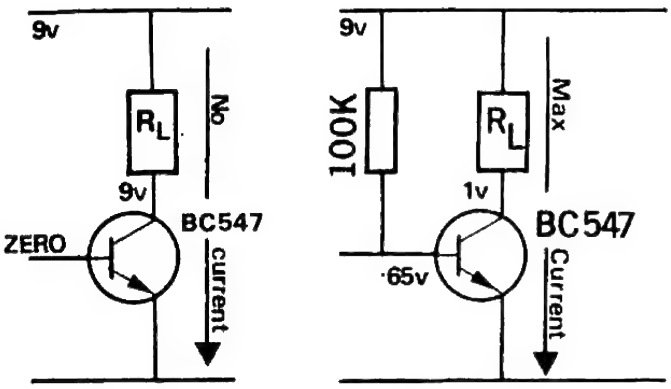
CONNECTING THE BASE TO POINT X: THE METER M1 WILL READ ZERO = CUT-OFF

AT POINT Y THE METER WILL READ 50mA = "PARTLY ON"

AT POINT Z THE METER WILL READ 100mA = SATURATION OR FULLY CONDUCTING.

When you see a transistor driving a relay, the first question you must ask is: "Is the transistor operating as a switch?" The answer will be "YES."
After all, the relay is only happy when it is open or when it is closed. It does not like to be half open, chatter or oscillate. So for these two conditions to be met, the transistor must be able to supply driving current sufficient to close the relay and then be able to pass zero current to allow the relay to open. We are not interested in other conditions as supplying "a little current" or "half current" as this would cause chatter.

These two transistor conditions produce two new words.
They are: SATURATION and CUT-OFF.



SATURATION is when a transistor is drawing the maximum allowed current. The voltage between the collector and emitter will be low and the relay will be energised. To create this condition, the base will need to be supplied with its full turn-on voltage of .65v.

CUT-OFF is the opposite condition. The transistor is drawing no current and the collector is at rail voltage. The voltage on the base is zero. The relay is not energised and no curent is flowing through its coil.

When a transistor is operating as a switch, it is functioning at the extreme ends of its range. The idea is to turn the transistor off (cut-off) and then turn it on (saturate) as quickly as possible. There is a decided advantage in passing the transistor through its mid-range as quickly as possible, as you will see.

These two extreme states depend upon the voltage applied to the base of the transistor. We will consider a silicon NPN transistor type BC 547. If we connect the transistor as shown in the diagram, with the base un-connected, the transistor will not conduct any current through the collector-emitter circuit and the transistor will be OFF, or to use the technical term: "CUT-OFF."

So, to turn the transistor on, we must provide a voltage on the base. The simplest method of achieving this is to insert a resistor between the positive rail and the base. The value of this resistor will depend on the type of transistor. It is our intention to turn the transistor on fully so that it is saturated. This requires a base resistor having a value which will allow sufficient base current to flow and then a little more. It is necessary to provide a small amount of overdrive to be certain that the transistor is fully saturated.

This means that the base resistor will be lower than normally required and may appear to be too low for the conditions. But this will ensure full saturation. For our example, we will chose 100k.

A 100k base resistor will develop a turn-on voltage of .65v and the transistor will saturate. The collector voltage will fall to about 1v so that most of the supply voltage will appear across the load. In our case, the relay is the load.

These two extremes are not only ideal for the relay but also most acceptable for the transistor. The reason for this lies in the power losses associated with driving loads such as relays or globes. It may be of little concern when dealing with a tiny transistor and a miniature relay, but these conditions will be multiplied for large equipment and the basic theory still applies.

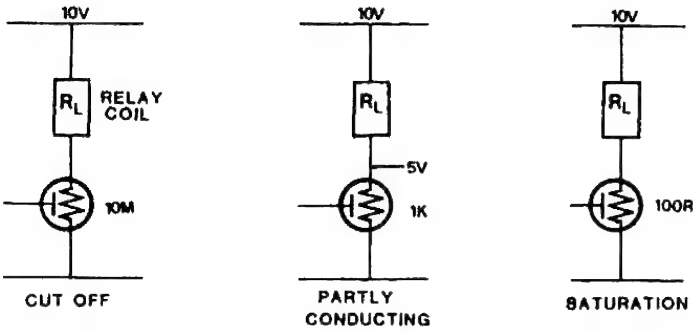
When a transistor is in saturation or cut-off, it dissipates the least amount of power. This is a very important consideration because the size of the transistor is dependent upon the power it is required to dissipate. By reducing this loss, the size of the transistor can be kept to a minimum and its life can be increased.

So, we have just created a situation which has benefits all round. Low power loss, good life expectency for the transistor and a perfect supply of on/of energy to the relay.

It's easy to understand that CUT-OFF dissipates little power because no power is being drawn by the circuit. But likewise, SATURATION dissipates minimal power when the maximum current is flowing.

To understand power loss in a transistor, we can compare it to a resistor in a DC circuit. The transistor can be thought of as a variable resistor. The three resistance values we will consider are: 10M, 1k and 100 ohms. These will correspond to the transistor in CUT-OFF, PARTLY CONDUCTING and SATURATED. The load R_L corresponds to the resistance of the relay coil and will be constant at say 1,000 ohms. (This value is not important).

The power dissipated by the transistor (the variable resistor) is dependent upon two factors. The voltage across it and the current flowing. These two values are multiplied together to obtain the power loss. It is this lost power which heats up the transistor and causes us a great deal of concern. Transistors



A TRANSISTOR CAN BE THOUGHT OF AS A VARIABLE RESISTOR.

do not like getting too hot and usually the rating of the device is dependent upon the wattage it can dissipate.

By reducing this loss, the life of the transistor can be extended. We have said that operating the transistor in CUT-OFF or SATURATION dissipates the least power, now we will look at why.

In the first diagram on the grid page, the transistor is effectively a 10M resistor. If the voltage supplied to the circuit is 10v, from Ohms Law, the curent flowing will be 1 microamp. The voltage across the transistor will be 10v so that the power loss will be 1 x 10   10 microwatts.

The centre diagram shows the transistor in a conducting situation somewhere between cut-off and saturation. We have called it a partly conducting condition. If we say the transistor is equivalent to a 1k resistor, the voltage on the collector will be 5v since the resistance of the relay is 1k and produces a voltage dividing network made up of two 1k resistors. The current flowing will be 5mA making the power loss 5 x 5   25 milliwatts.

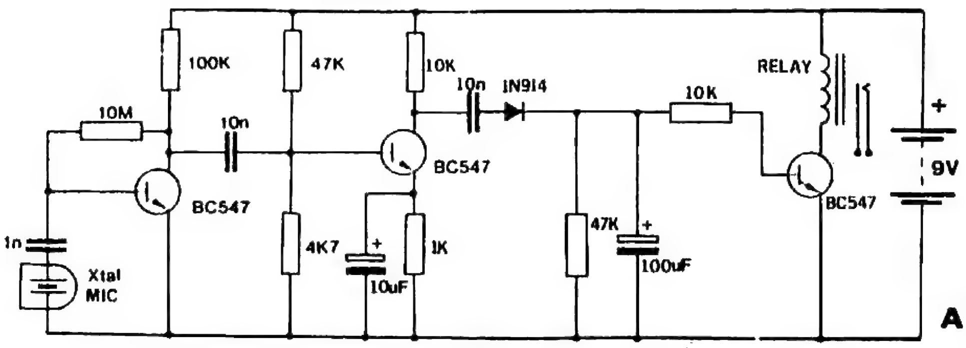
The third diargram shows the transistor in saturation. It can be thought of as equivalent to a 100 ohm resistor. The circuit becomes a voltage dividing network in which the transistor has about .9v across its collector and emitter terminals. The current flowing will be about 9.9mA, so that the power lost in this transistor is .9 x 9.9   8.9 milliwatts.
This shows less power is being lost in the saturated condition, even though twice the current is flowing than in the partly turned-on condition. In reality, most of the heat is generated when the transistor is passing from the cut-off condition to the saturated condition.
For this reason, it is important to take the transistor through this intermediate zone as quickly as possible.
In practice, there are limitations to this, mainly due to the delay times inherent in the design of the transistor and the speed of the switching voltage. The fastest switching times are achieved when a square wave is applied to the base since the rise-time is very brief. But not all waveforms are square wave. We have to accept the shape of the incomming waveform and design the switching stage to be as fast as possible.

When this has been achieved, the transistor is operating just like a switch. This arrangement will have the lowest power losses and will allow the transistor to drive the largest load with the longest life expectancy.

Back to the VOX.

We will now combine all the points we have described to create a switching output stage.

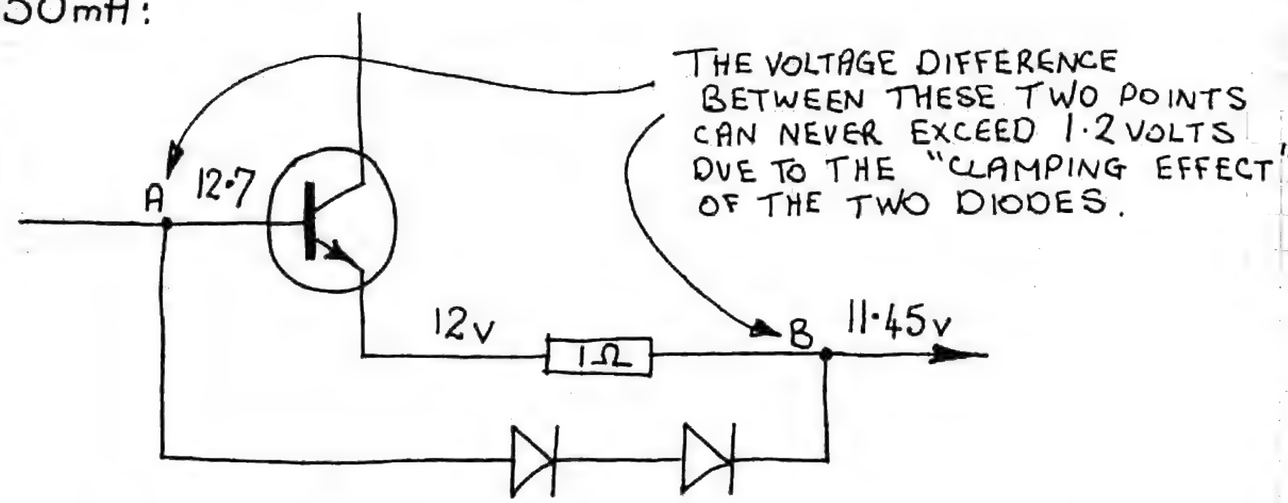
The audio from the amplifier is rectified by the diode and stored in the 100mfd electrolytic. The 47k resistor provides a load for this charging operation. The 10k resistor is a base buffer to enable the 100mfd to charge beyond .65v . It should also be low enough to provide full saturation for the transistor. The electrolytic will charge very quickly to .65v and will continue to charge to a higher voltage and keep the transistor turned on. When the audio signal ceases, the accumulated high voltage on the electro will be used by the transistor like a miniature rechargable battery. After a short time the voltage will drop to below the turn-on voltage and the relay will be released. ●



A VOX CIRCUIT

AT 500mA THE VOLTAGE BETWEEN POINTS A AND B HAS INCREASED TO 12·65 − 11·5 = 1·05 VOLTS. THIS IS STILL BELOW 1·2 VOLTS AND THUS THE DIODES DO NOT HAVE ANY EFFECT AT THIS CURRENT FLOW.

@ 550mA:



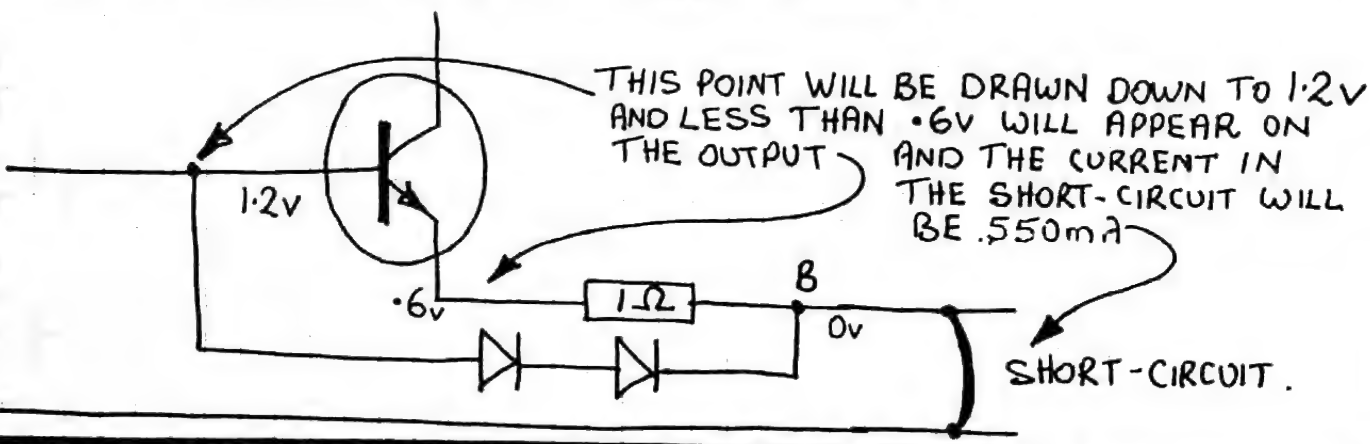
AT 550mA THE VOLTAGE LEVELS ARE SHOWN IN THE DIAGRAM ABOVE. THE TRANSISTOR HAS TURNED ON SLIGHTLY HARDER TO DELIVER THE CURRENT AND THIS HAS PRODUCED A VOLTAGE DIFFERENCE OF 12·7 − 11·45 = 1·25. NOW THIS IS GREATER THAN THE DIODES PERMIT AND ANY FURTHER ATTEMPT AT INCREASING THE CURRENT WILL LOWER THE OUTPUT DRAMATICALLY.
YOU SEE THE DIODES ARE NOW COMING INTO PLAY AS THE VOLTAGE ACROSS THEM HAS RISEN TO 1·2 VOLTS.

ANY INCREASE IN CURRENT WILL LOWER THE OUTPUT VOLTAGE (DUE TO THE VOLTAGE DROP ACROSS THE 1Ω RESISTOR) BUT THIS VOLTAGE WILL NOW BE PASSED STRAIGHT BACK TO THE BASE VIA THE DIODES AND THIS WILL TURN THE TRANSISTOR OFF. THIS WILL GIVE A LOWER OUTPUT VOLTAGE.

THE NET RESULT WILL BE A REDUCTION IN OUTPUT VOLTAGE SUCH THAT THE MAXIMUM CURRENT FLOWING WILL NOT EXCEED 550 mA.

[AS YOU KNOW A LOWER VOLTAGE APPLIED TO THE LOAD WILL RESULT IN A LOWER CURRENT FLOW − DUE TO OHMS LAW]

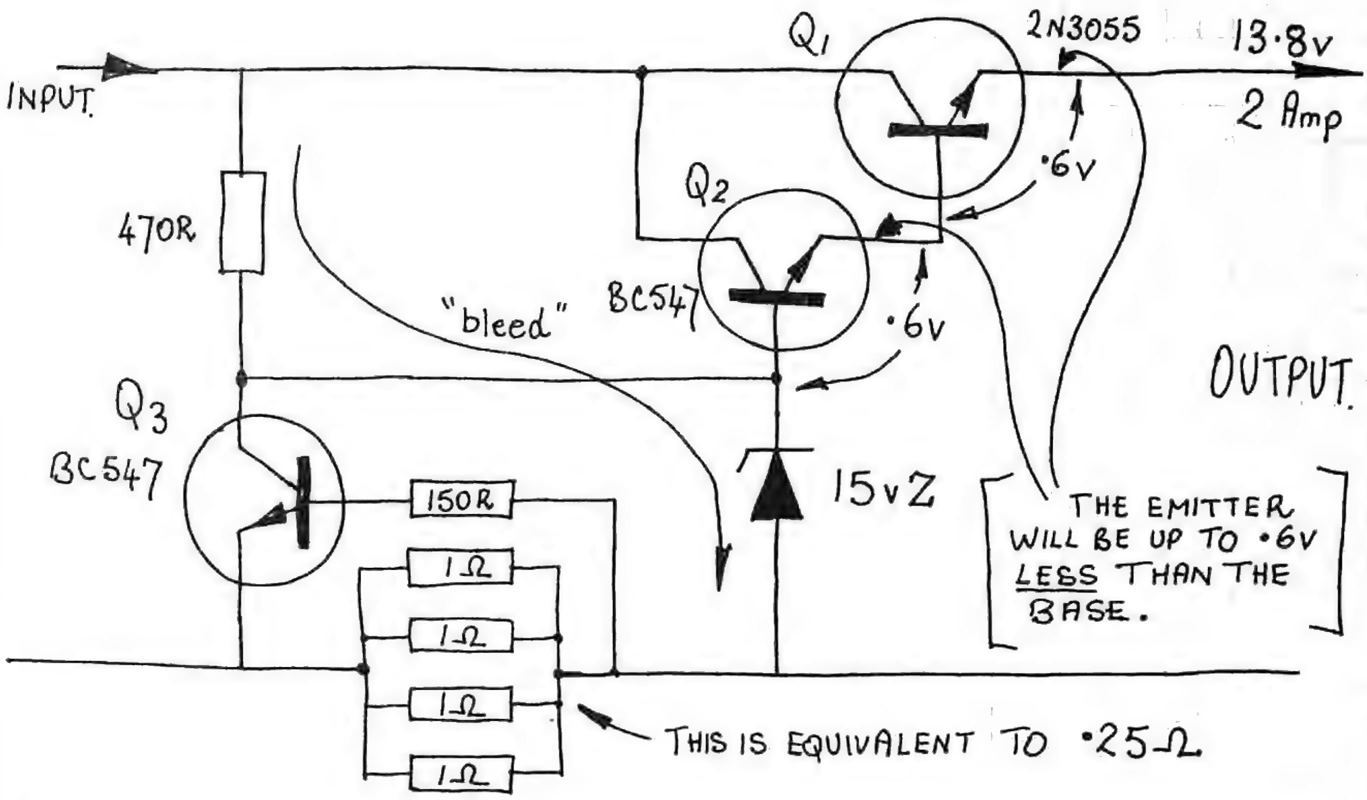
TAKE THE EXTREME CASE OF A SHORT-CIRCUIT:



THE MAIN DISADVANTAGE WITH THE PREVIOUS METHOD OF PROTECTING THE CIRCUIT AGAINST OVERLOAD WAS THE VOLTAGE DROP NEEDED TO OPERATE THE SENSING CIRCUIT. FROM NO-LOAD TO FULL-LOAD A ·5V REDUCTION IN VOLTAGE WAS INTRODUCED.

THIS STABILITY IS NOT GOOD ENOUGH FOR SOME EQUIPMENT. TAKE A TV SET FOR INSTANCE. SOME SETS ARE DESIGNED ON A RAIL VOLTAGE OF ONLY 11 VOLTS. A CHANGE OF EVEN ·2 VOLTS WILL CREATE LACK OF WIDTH OR HEIGHT. SO IMAGINE THE EFFECT OF ·5 VOLTS. (THIS CHANGE IN VOLTAGE WOULD RESULT FROM THE VARYING BRIGHTNESS LEVELS & THIS WOULD ALTER THE CURRENT REQUIREMENTS).

A CURRENT LIMITING CIRCUIT CAN BE PLACED ON THE INPUT SIDE OF THE PASS TRANSISTOR WHERE IT WILL HAVE THE LEAST EFFECT ON THE OUTPUT VOLTAGE. THE FOLLOWING CIRCUIT SHOWS THIS:



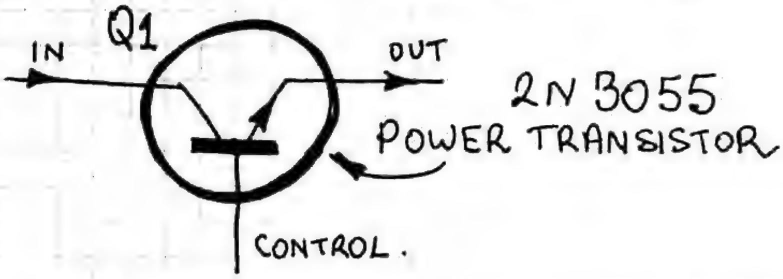
IN THIS CIRCUIT Q1 IS THE SERIES PASS TRANSISTOR, Q2 IS THE SENSING AMPLIFIER AND Q3 IS THE OVERLOAD DETECTOR.
WE HAVE SEEN HOW Q2 OPERATES. IF IT WERE REMOVED AND THE ZENER DIODE CONNECTED TO THE BASE OF Q1, THE BLEED CURRENT WOULD NEED TO BE AT LEAST 10 TIMES GREATER. (SEE THE PREVIOUS REASONING FOR THIS) Q2 SERVES TO AMPLIFY THE VOLTAGE IT DETECTS ON ITS BASE TO SUPPLY Q1 WITH THE REQUIRED CURRENT AS Q1 WILL NEED AT LEAST 20mA BASE CURRENT & POSSIBLY MORE LIKE 50mA.
ACTUALLY THE CURRENT
THIS ALLOWS THE ZENER DIODE TO HAVE A LOWER BLEED CURRENT.

UNDER NORMAL CONDITIONS Q3 IS NOT TURNED ON AND PLAYS NO PART IN THE OPERATION OF THE CIRCUIT.

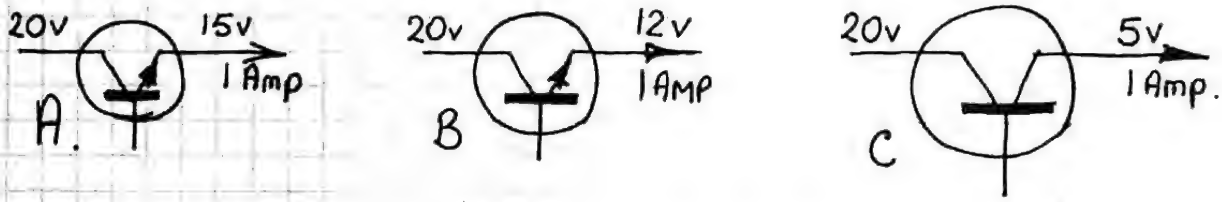
THE 4 1Ω RESISTORS IN PARALLEL COMBINE TO FORM A ·25 Ω RESISTOR, AND WHEN THE CURRENT APPROACHES 2 AMPS A VOLTAGE OF ·25 × 2 = ·5 VOLT WILL DEVELOP ACROSS THE COMBINATION. THIS BEGINS TO TURN ON Q3 AND IF THE CURRENT INCREASES FURTHER Q3 WILL TURN ON FULLY TO SHORT-OUT MOST OF THE ZENER DIODE VOLTAGE. THE BASE OF Q2 WILL THEN SEE A VOLTAGE AS LOW AS 3 – 4 VOLTS. THE EMITTER OF Q2 WILL FOLLOW THIS FALL WITH A VOLTAGE ON ITS EMITTER OF 2·4 – 3·4 VOLTS. THE OUTPUT OF Q1 WILL REDUCE TO 1·8 – 2·6 VOLTS.

IF THIS LOW VOLTAGE IS CAPABLE OF SUPPLYING THE 2 AMPS, AS IN A SHORT-CIRCUIT CONDITION, THE CIRCUIT WILL REMAIN IN THIS SHUT-DOWN MODE. THIS MAY BE PROTECTING THE EQUIPMENT BEING SUPPLIED BUT THE POWER SUPPLY ITSELF WILL BE SUFFERING GREATLY AS WE SHALL SEE IN THE NEXT SECTION.

POWER-LOSS IN A SERIES REGULATOR



THE SERIES PASS TRANSISTOR Q1 CAN BE THOUGHT OF AS A RESISTOR WHEN CONSIDERING THE POWER LOSS IT MUST DISSIPATE.
TAKE THESE THREE CASES:

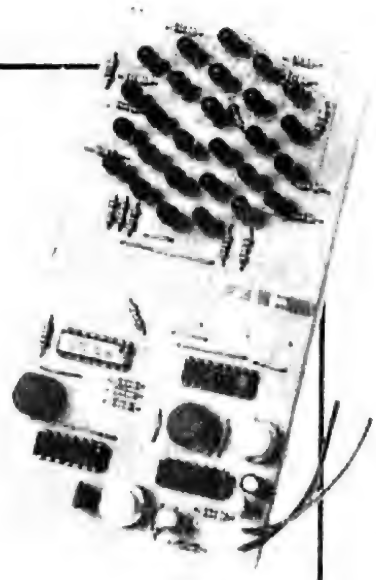


IN THESE 3 EXAMPLES A B & C, THE OUTPUTS ARE 15v 12v & 5v. @ 1AMP WHICH TRANSISTOR WILL HAVE THE GREATEST HEAT LOSS? IN OTHER WORDS, WHICH TRANSISTOR WILL HEAT UP THE MOST? YES! C! THE REASON IS SIMPLE. THE TRANSISTOR IS DROPPING THE MOST VOLTAGE (OF THE 3 CASES). THE TRANSISTOR IS EFFECTIVELY A DROPPER RESISTOR AND MUST DISSIPATE HEAT ACCORDING TO OHMS LAW.

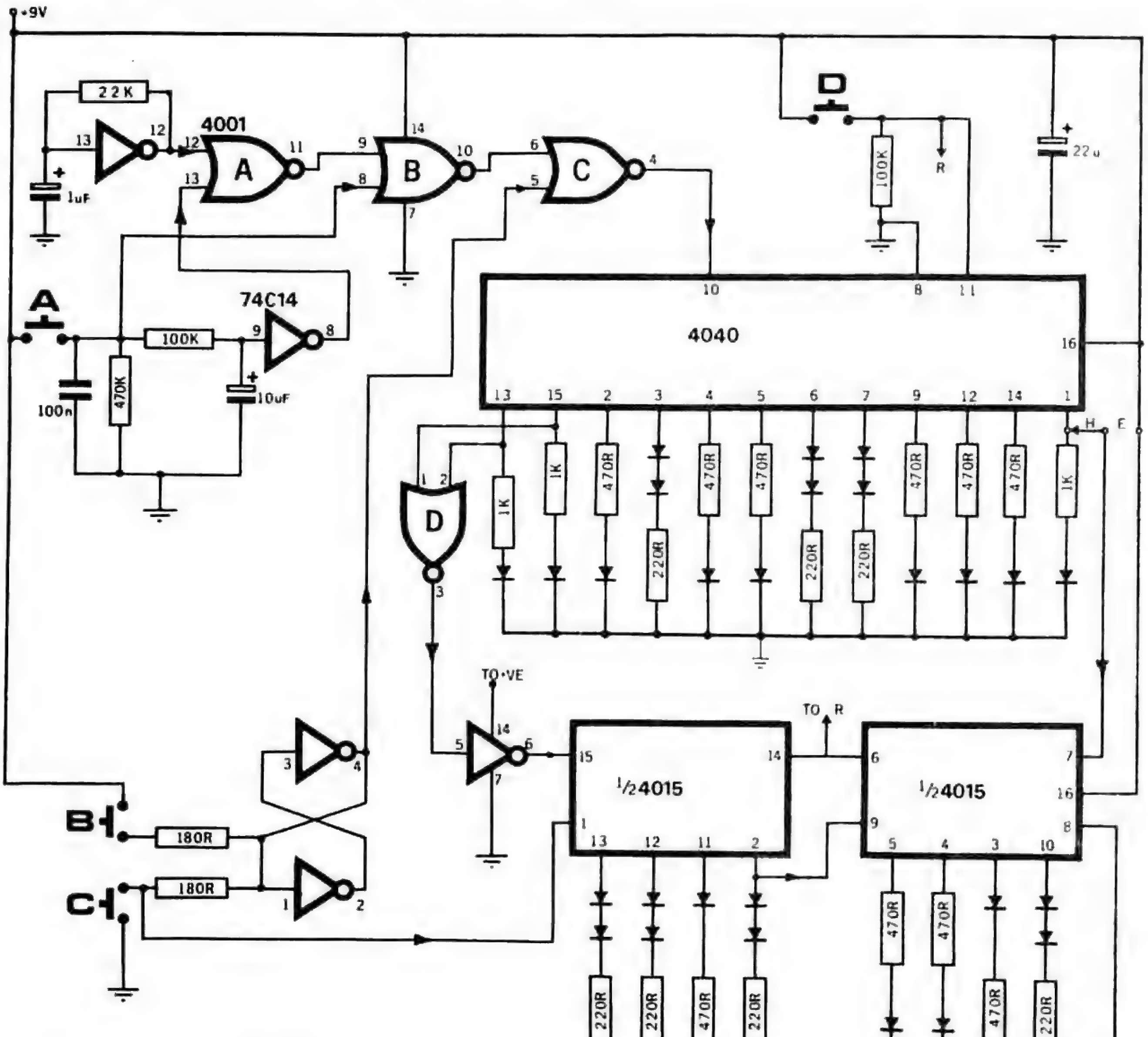
IN CASE A THE VOLTAGE ACROSS THE TRANSISTOR IS 20 – 15 = 5 VOLTS AND THE WATTAGE BEING DISSIPATED IS 5 × 1 = 5 WATTS.
IN CASE C THE WATTAGE IS 15 WATTS – A CONSIDERABLE INCREASE.

IF THE OUTPUT OF A POWER SUPPLY IS SHORT-CIRCUITED THE WHOLE INPUT VOLTAGE WILL BE DROPPED ACROSS THE POWER TRANSISTOR AND WILL RESULT IN ENORMOUS HEATING PROBLEMS. FOR THIS REASON THE REGULATOR TRANSISTOR MUST BE EFFECTIVELY HEAT SINKED.

CUBE PUZZLE



Frustrate yourself with this electronic CUBE PUZZLE. . . .it will appeal to young and old alike.
It uses readily available components and can be built in an afternoon. Using a dual colour PC board, colourful components in the switches and LEDs, it becomes a really great model.



The CUBE PUZZLE circuit.
Note: The arrows show the direction of the signal(s).

First came the cube, then the book and finally the cube hammer.

So popular did the cube become that no fewer than a dozen "How to solve it" books appeared on the market. Additionally, the cube came in so many shapes and sizes that almost every house-hold in the developed world suffered the anxiety and frustration of one or more of its members trying to unravel the secret of its solution.

And so it struck our household. As the price of cubes began to fall: firstly one, then two and finally three cubes came into my possession. Even though they were all designed around the same ingenious jointing system, the offered different incentives. Some were fully a cube, others had their corners removed while one had a number of projections.

Possibly the most frustrating aspect of the cube saga is the speed with which some adept youngsters can solve it. Even openly admitted by it inventor, these young intellects are emphasising the expansiveness of our mind; being able to comprehend, interpret and plan many moves ahead to arrive at the incredible time of 23 seconds for a solution to a puzzle having a hundred thousand million combinations!

Throughout all of this cube craze, nobody thought of an electronic cube puzzle. Well, I did! I couldn't let this opportunity pass by without cashing in on the possibilities of an electronic version.
Obviously without any mechanical manipulation of the pieces we would have to resort to a different interpretation. Instead of shifting the pieces around in 3-dimensions, it would only be possible to use coloured LEDs. The result of our efforts is the CUBE PUZZLE.

If you have a feeling for electronics and like to get frustrated - the Cube Puzzle is for you. At least you can be certain no one will able to solve it in 23 seconds - it took us over 5 minutes to solve!

Our project is an isometric representation of 3 faces of a cube. You are required to illuminate all the 27 LEDs by pressing the 4 coloured push buttons. This may seem easy but in effect the number of combinations is in the order of millions. It's only after playing with the puzzle for an hour or so that you can piece together some of the patterns for pushing the buttons. After this, you will need to put the individual steps together in the correct sequence to solve the puzzle.
All in all, it is just the thing for frustrating other members of your family. The fact that the readouts illuminate, make it ideal for nightime use such as if you are stuck in bed for a few days. Also it would make an ideal present for very junior friends as it will develop co-ordination and concentration and maybe give you a happy surprise when he comes back with it fully lit.

Photographs and diagrams do not do justice to this project. The PC board is much more colourful and effective than presented . We have used 2 colours on the PC board to give the appearance of the corner of a cube and the coloured LEDs add to the effect. You can use any coloured LEDs you wish however one point worth noting is the different voltage drops produced across the various colours. For red LEDs this voltage is 1.7v, for green LEDs the voltage is 1.9v and for yellow or orange LEDs the voltage drop is 2v. In this project we are driving 2 loads from three of the outputs and under these conditions it is important to keep the same colour scheme as per our model. We used orange LEDs for the top face, red LEDs for the left hand side and green LEDs for the right hand side. This arrangement will satisfy our set of dropper resistors and you will see the reason why we have had to increase the value of three 470R resistors to 1k to allow the voltage at these points to rise above ½ rail voltage and clock the next chip.

You will be happy to know, there is one small point to this project which we will not be releasing. The answer.

Parts list

2 - 180R
7 - 220R
10 - 470R
3 - 1k
1 - 22k
2 - 100k
1 - 470k

1 - 100n 100v greencap
1 - 1mfd 16v electro
1 - 10mfd 16v electro
1 - 22mfd 16v electro

4 - push buttons

1 - CD 4001 IC
1 - CD 4015 IC
1 - CD 4040 (or CD 4020) IC
1 - 74c14 IC (CD 40106 or CD 40014)

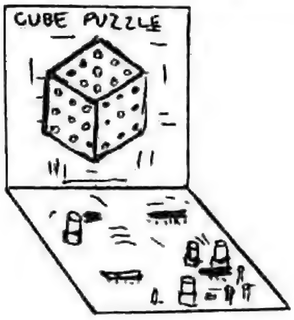
9 - 5mm Red LEDs
9 - 5mm Orange LEDs
9 - 5mm Green LEDs

tinned copper wire
1 - Battery snap

Unfortunately we cannot provide you with a detailed diagnosis of the sequence of events and keep the solution a mystery.
So we have had to with-hold some of the instruction material and fault finding sequences.

Rest assured that the puzzle will operate as designed if you take care with the soldering and insert the parts as shown on the overlay in the article. Some of the 470R resistors on the overlay have been increased to 1k to take into account the spread of parameters for different LEDs and IC's. The three 1k resistors are clearly mentioned in the construction notes.

Across the centre of the board, on the PC side, you can see a row of lands looking like an edge connctor. In fact this is a form of edge connector which can be cut across the middle and the two halves of the board set at right angles as shown in the sketch.



If you want to make the PC board into a bracket in this manner, the cutting and soldering of the connecting wires should be done before the parts are inserted. To do this, cut the board and lay the two pieces together with a small gap. Join the lands with a tinned copper wire and when all the lands are connected, bend the board up to form the shape shown.

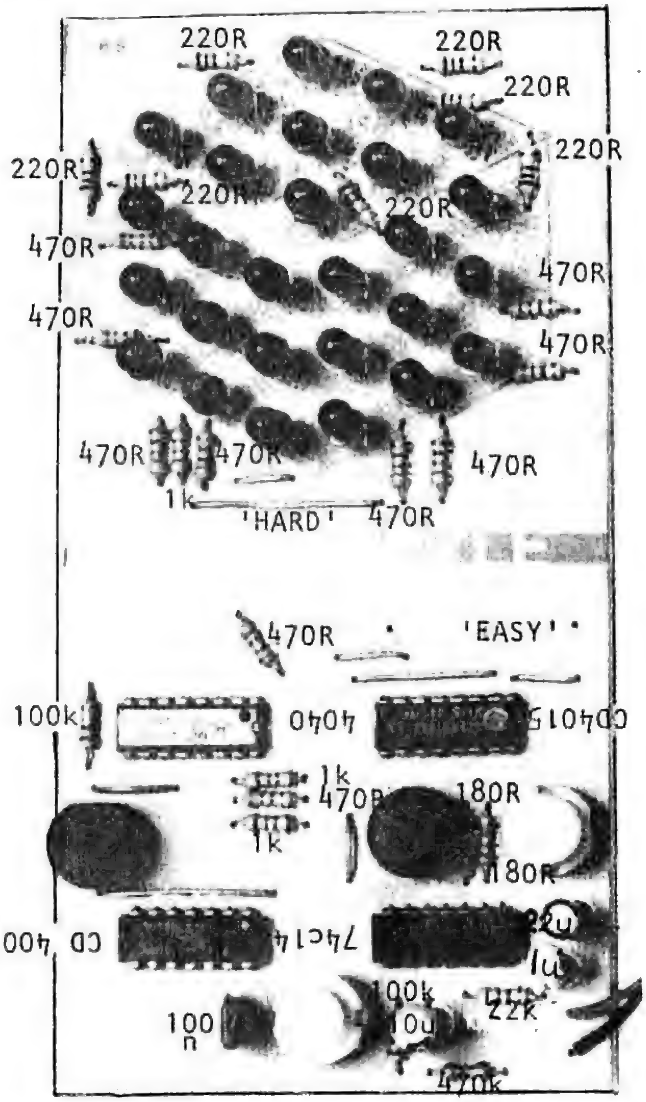
HOW THE CIRCUIT WORKS

The operation of the circuit can be described without giving away any clues to solving the puzzle.
This is important if you think your puzzle is not operating correctly

The cube puzzle contains only 4 buttons and they function in conjunction with one another to give 5 operations. We will list the buttons as A,B,C,and D on the circuit diagram but not identify them on the PC board at this stage.

The heart of the cube puzzle is a clock. On the circuit diagram this is hidden in the top left hand corner. It is produced by the inverter between pins 13 and 12 and uses a 1mfd electrolytic and 22k resistor as the timing components. This clock operates all the time the battery is connected and its output is gated via three NOR gates before it finally gets to its destination - a CD 4040 binary counting IC.

The first inhibitor is the NOR gate made up of pins 12 13 and 11. This gate operate such that the clock pulses are prevented from appearing at the outpt when the gating pin (pin 13) is HIGH.



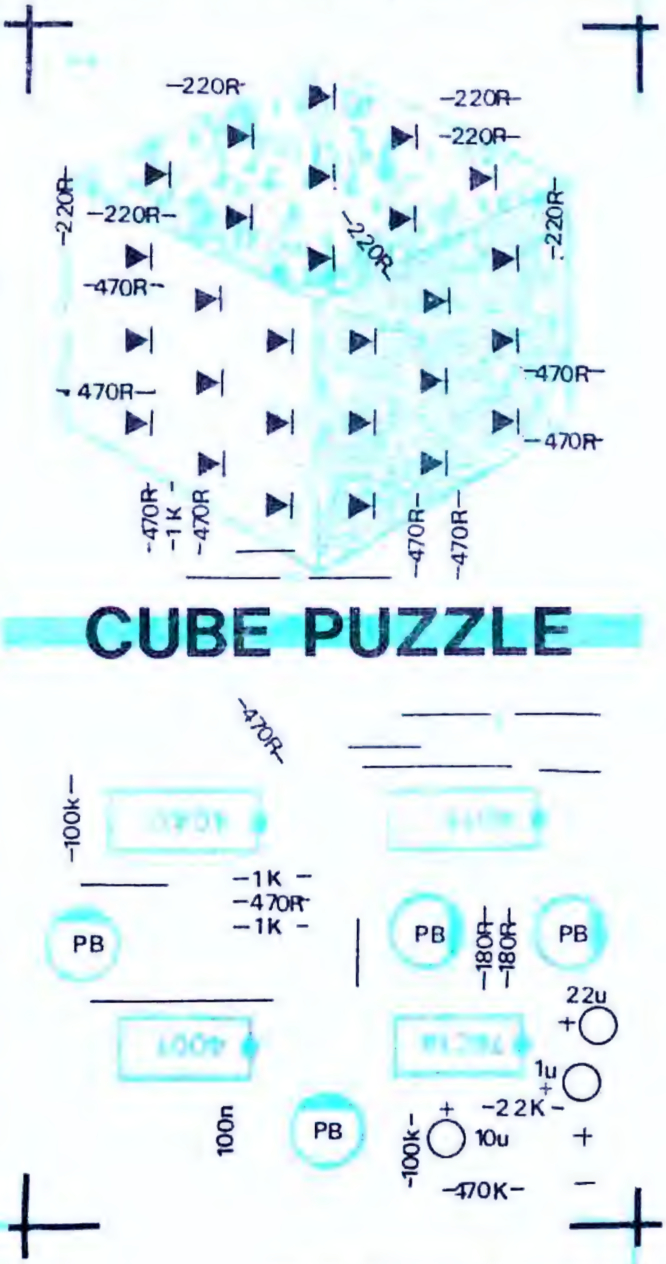
The completed project with all parts identified. We wired our model with the HARD link but for starters you should use the EASY link.

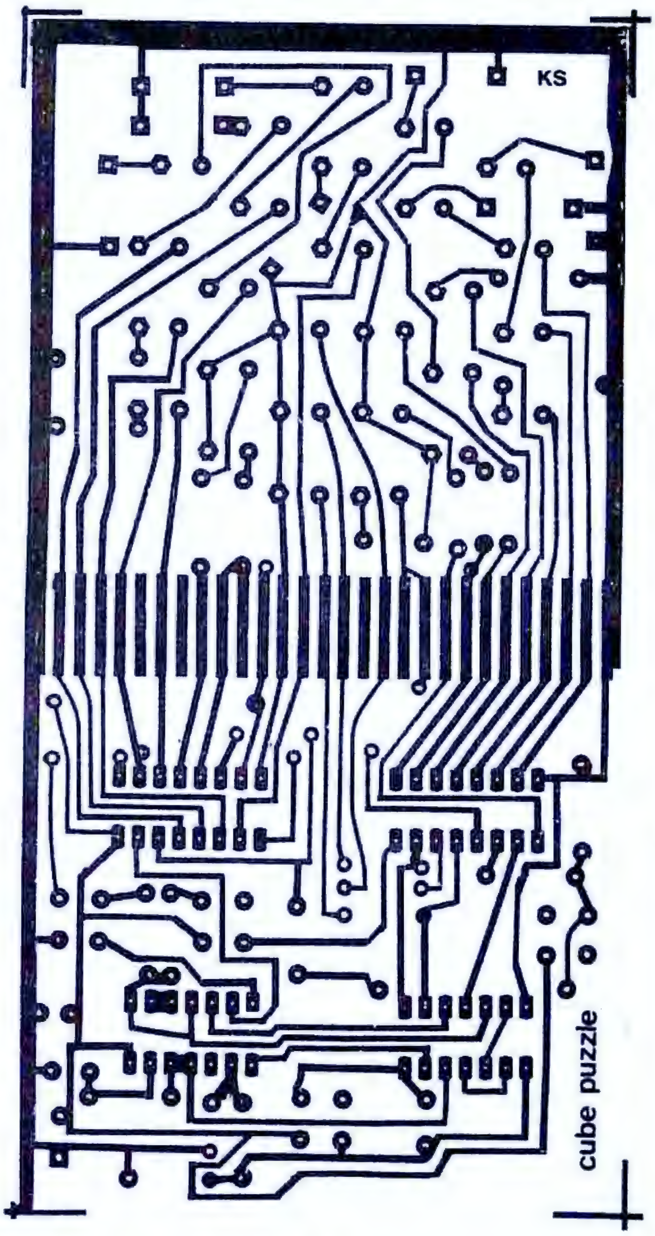
This control line emerges from a schmitt trigger and under quiescent conditons (idling conditions), the output of the inverter is HIGH. This is due to pin 9 of the 74c14 being LOW. The input voltage for this inverter is obtained from push button A. This button also feeds another circuit (which is pin 8 of the NOR gate b) but this does not have any effect on the section we are describing at the moment.
When button A is pressed,and released the 10mfd electrolytic charges via the 100k resistor. For the inverter to change state, the voltage on its input pin must rise to more than ⅔ of the supply voltage. Button A must be

pressed for about 1 second to achieve this. When the button is released, the 470k resistor and 100k resistor bleed the voltage from the electrolytic and the schmitt trigger enables gate 'a' to pass the clock pulses during the interval of time the electro is discharging down to ⅓ supply voltage. However the voltage at the join of the 100k and 470k resistors is some times above 50% of the rail voltage and during this condition gate 'b' sees a HIGH on its input pin 8 and this prevents the pulses from passing through NOR gate 'b'. It is only when the voltage falls to below 50% and above 33% that the pulses are passed to the third NOR gate. This narrow acceptance level produces the time lag on button A and produces some unexpected clocking of the display, just when you want to one-shot the puzzle.

The 100n capacitor provides debounce for the push button so that you can one-shot the NOR gate shown as gate 'b'.
At rest, pin 9 will be at zero so that this gate will pass the pulses from switch A and these will appear at pin 10. Providing pin 5 of the 3rd NOR gate (c) is LOW, these pulses will be passed to the 4040 binary counter IC.

The clock signal has no more obstructions before passing to the 4040 counter however we have incorporated one more surprise into this part of the circuit. The binary counter has an enormous number of counting stages and will accept 4069 pulses before all the outputs are HIGH. We have distributed these outputs over the whole display so it is difficult to detect the binary readout.





The layout is produced in 2 colours to highlight the cube diagram. Note the positioning of the 4 IC's.

If that isn't enough!

An even more involved circuit is produced by the CD 4015 shift register. More accurately speaking, it is the origin of the data and clock lines which make the shift register so difficult to crack. You can only write into the first register when a combination of facts is present on the 4040 IC and the clock line. The 4015 has 2 separate shift registers and requires 2 separate input routines. One register can be filled when pin 13 or 15 of the 4040 is HIGH and the buttons B&C toggled.

The second register has two degrees of difficulty. Selecting the EASY mode will mean the data pin is kept HIGH and by toggling the clock pin 9, the register will be filled. This means the first register must be filled with alternate HIGHs - a situation which is not immediately evident.

In the HARD mode, the data line is HIGH for only the second half of the game and we will leave you to find out when this occurs.

A Bistable switch made up of 2 inverters is activated by buttons B and C. These inverters are forced into one state or the other and remain in this state to form an ON/OFF switch. This will start/stop the clock pulses as well as provide a set of HIGHs and LOWs for the shift registers.

BEFORE CONSTRUCTION

Possibly you are aware that the PC board can be cut across the middle to make a right angle. You will need lengths of tinned copper wire to connect the two boards together and this will give you a board which can be used flat or bent upright.

Personally, the idea behind the project was to produce a very flat puzzle to take the place of a card such as you would give to someone in hospital or for a birthday. I think we have achieved about the closest possible arrangement. By using standard components and 4 coloured push buttons, the 2-colour board and three colours of LEDs will produce a very presentable project.

One other decision you will need to make before construction is the choice of EASY or HARD solution. A jumper wire is needed across either the 'E' line or the 'H' line. The project will not work if you use both lines. Nor will it work if they are both left off. I suggest you use the EASY line for a start and get to crack the puzzle. Then you can change it to HARD and give it someone else.

CONSTRUCTION

The first components to fit onto the board are the resistors. These are all identified on the board, except for three alterations. The group of threee resistors mounted above the word CUBE is now changed to a 1k resistor in between two 470R resistors.
The group of three resistors located between the 4040 and 4001 chips has been altered to 1k resistors at each end and a 470R in the centre.

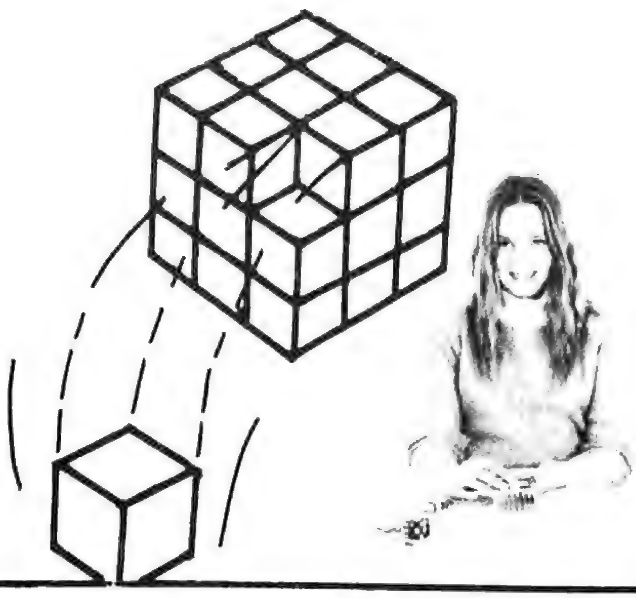
The next items to add to the board are the 8 links. Nine links are identified on the board but only the H link or the E link is to be fitted.

Fitting the LEDs is an easy operation. They all fit around the same way and are placed in groups of nine to represent the sides of a cube. Our model has orange LEDS at the top, red LEDs at the left and green LEDs at the right. You will now be seeing a little colour coming into the project.

Fit the 4 IC's to the lower half of the board. These are all inserted with pin 1 on the right hand side. See the overlay for pin 1 identification. The writing on the chips may be upside-down but never go by the printing on an IC as it has no bearing on the location of pin 1.

The last items to be fitted are the three electros, a 100n capacitor and 4 brightly coloured push switches. These switches must be connected as shown on the overlay as the connecting wire inside the switch is acting as a jumper link. Finish the board with a battery snap and it's ready to go. (2 holes on the H jumper will be vacant).

Now its up to you. I won't say any more. I'll let you get as frustrated as some of our staff.
If you have any queries, write to Ken Stone. He is responsible for the design.



SHOP TALK

GETTING YOUR ELECTRONICS COURSE TOGETHER

In the last two weeks I received a couple of course outlines covering the study of electronics at secondary level.
I was most impressed with the content of one of these. It was designed to cover the basics of electronics in both a practical and theoretical manner as well as studying the electronics industry and its interrelation with associated suppliers.

This is a most important aspect. Electronics is not an industry all on its own. It needs a whole host of suppliers to keep it functioning. At least 10 which come to mind are: the plastics industry, paper in dustry, inks, sheet metal,packaging, printing, marketing, chemical, rare metals, etc etc.
In fact, if you were to take away these supply industries, electronics would collapse.
The study of electronics is an enormously varied and intresting field. Designing a well-balanced syllabus is a difficult task.
To help you prepare for this type of course, I have included the syllabus in detail.
You will be able to see that TALKING ELECTRONICS covers almost half of the topics and why it is required reading in so ,many schools.
Although I would like to see more digital topics covered in any course, I realize the enormous amount of material which should be covered in any broad course. I also know the importance of knowing a little about the supply industry. I have had a few years experience in the plastics industry **the printing industry as well as** marketing sales and education. These have proven invaluable when designing a project and more so when starting up this magazine.
Unfortunately, with a time limit of 3 hours per week, only the more relevant information can be included in the course.
This is the ELECTRONICS TECHNOLOGY COURSE:

To satisfy the requirements of this syllabus, students will apply know ledge and understanding:

* to complete practical projects based on the specialised area chosen.
* to study the technology of an industry related to the area of study undertaken
* to study an over-all view of the industry.

GENERAL OBJECTIVES

The course will provide practical experiences which enable students to:
1. Gain experience in designing and planning projects.
2. Convey and interpret ideas in graphical form.
3. Understand the relationship that exists between properties and the application of materials encountered in the project.
4. Develop competence in relevant technical skills.
5. Develop an appreciation of quality in craftsmanship.
6. Use equipment, **machinery and** tools correctly and safely.
7. Further develop literacy and numeracy skills through experiences related to course study.
8. Experience satisfaction and enjoyment through involvement in projects which give a personal sense of achievement.
9. Develop an understanding of the basic structure of an industry which is related to the technology being studied.
10. Acquire a knowledge of the current, alternative and developing processes and techniques used by the selected indstry.
11. Develop an appreciation of the relationships between technology, the individual society and the environment.
12. Acquire a knowledge of the social and physical environment within an industry through work station experience, which may be by participation, observation or class simulation.

These are the objectives of the course:
To be able to develop electronic circuits using discovery-learning techniques.

To be able to draw and interpret circuit diagrams.

Be able to recognise the structure and function of electronic components.

Be able to analyse circuit using test equipment.

Be a discriminating consumer in the electronics market.

Use tools and test equipment in a correct manner.

Know the basic principles of electricity and electronics.

Be able to apply the relevant principles of logic to electronic circuits.

Be able to construct well-finished, functional models.

Understand the structure of the electronics industry.

Apply a systematic, step-by-step approach to fault-finding in electronic circuits.

Be able to interpret the findings displayed on test equipment.

Have a knowledge of the social and physical environment within the electronics industry.

Recognise the impact of electronics on our society.

Know the historical development of the industry.

Have further developed literacy and numberacy skills through experiences related to electronics technology.

CONTENTS OF THE COURSE

Electricity Supply:
Power sources - hydro, wind, geothermal, steam, nuclear, coal, internal combustion engine, solar, batteries.
Distribution: line voltages and use of transformers, grid system,fuses, circuit breakers, earth leakage detection.
Safe Use of Electricity: regulations, SAA codes,resuscitation.
Electronic Numeracy:
Circuit Laws: Ohms's Law, Kirchoff's Laws, series cirucits, parallel circuits, R/C networks.

Basic Principles of Electricity:
Voltage, DC, AC, rectification, current resistance, power, inductance, capacitance, magnetic fields, electromagnetic fields.

Electronic Components:
Historical development, manufacturing methods, conductors, insulators, resistors, thermistors, LDR capacitors, vacuum tubes!! semiconductors, diodes, transistors, coils, solenoids, relays, transformers, speakers, switches.

Component Codes:
resistor colour code, IEC capacitor code, preferred values.

Circuits:
series, parallel, tunes, amplifiers, oscillators, timing, detector.

Integrated Circuits:
Development, manufacturing methods, functions of some common IC's (555, 741)application of some common IC's.

Digital Electronics:
Logic, Boolean Algebra, Binary System, Logic Families, TTL, CMOS, Logic gates: AND, NAND, OR, NOR, NOT.
Truth Tables, application of some digital IC's. (4001, 4011), Oscillators, Counters, displays.

Circuit Testing Equipment:
Use of the following: continuity tester, voltmeter, ammeter, multimeter, transistor tester, audio oscillator, Cathode Ray Oscilloscope, logic probe, signal tracer.

Associated Graphics:
Circuit symbols, circuit diagrams, PCB design, component layout, drawings associated with housing the project. SAA code.

Practical Skills:
wire stripping, soldering, de-soldering, making and etching printed circuit boards, component layout and dress, wire wrapping, handling precautions, construction on bread-board and proto board, tag strips and printed cirucit board.
Circuit design, drawing cirucit diagrams using test equipment, fault finding, use and application of allied materials.

Assessment:
Written Examination 30%
Project assessment 70%

A few additional features of this course involve the assessment of the candidates work by a team of external assessors. This will take the form of a 30 minute interview in which the candidate will present his projects and be asked questions relating to them.

KALEX AWARDS

For the past few years, the only competition I have been informed about, for junior electronic hobbyists has been the Kalex Awards. This year is no exception. Once again they are offering a really great range of prizes, totalling more than $1,000. These will be spread over a number of different sections.

If you would like to know more about the categories and rules, you should ask your careers co-ordinator or electronics instructor. It is run in conjunction with the Electrical Electronic Practices Standing Committee. Even though it is only open to students in Technical and High Schools, I am releasing the few details I have to hand in an effort to further promote this type of activity. Everyone likes competition. It's the fastest way to find out the capabilities of your fellow workers or the opposition.

We are fully behind this competition. Even though we are not providing any of the prize money, we have assisted in the production of some of the material for one of the sections. Basically it is our LED dice project as featured in issue 5 and the entrants are required to construct their own PC board and mount the components on it.

But even if your are a complete beginner, you are catered for. A category exists which requires only the knowledge of identifying components and neat soldering. Other sections ask for the assembly of a simple electronic circuit and the top section poses a problem in electronics in the form of distant signalling using a carrier signal through the air.
Depending on your age and knowledge of electronics, you will be able to find a section which tests your ability and allows your present your capabilities.
For me, the best part of the competition is the fact that it is almost entirely digital. Nearly all the main circuits use a chip, and this pleases me greatly. The competition next year may see the use of two or three chips in one of the categories and this will be real progress.

ENTER THE KALEX COMPETITION - IT's OPEN TO TECHNICAL AND HIGH SCHOOL GROUPS

Now I am asking you for assistance. If you are currently entering a competition or know of one, please send the details to us. At some later stage we may be able to co-ordinate these to provide bigger and better prizes. This would also provide a wider scope for entrants and allow such circuits as mini computers and synthesisers to be included in the judging. What a great possibility!

A SMASHING SITUATION

All our major kits are now packed in plastic boxes. This makes it easy to pack and adds a lot to the presentation. It also makes it easy for us to assemble the kits as they are produced on an assembly line in lots of 100.

Although these boxes are not the strongest in the world, they will withstand a load of at least 10kgm before cracking and it would take a fall from a three-storey building to smash them.
I refer to the situation when these boxes are fitted inside a jiffy bag as required by the postal authorities. Everything goes well at our end. They leave our hand in an undamaged condition. We don't tread on them, or throw them from one end of the assembly room to the other. And yet when they arrive at their destination, through the post, it looks as though a truck has run over them. Twice this has happened. Even the components inside the box have been crushed. Mr E. Davis of Kadina did the right thing. As stated in his own words..."An order for parts I received from you recently looked as though it had been run over by a truck. The plastic box containing the parts for the LOGIC DESIGNER was completely shattered. The 200 600 Designer Board was fractured in two places and the FND 500 was chipped. The leads were twisted in all directions. I was so mad, I took the package straight round to the Post Master and emptied the contents onto his desk. As a result, I have been promised reimbersement for replacement of the badly damaged items and for the postage.
In case you are not aware, all articles posted in a jiffy bag are covered by $20 compensation. If the contents of any project are damaged in one of these bags, you should immediately present the evidence to your local Post Office.
This is a bone of contention, not only from ourselves, but from a number of other mail order houses. Damage to postal items. The time has come when mail-bag distribution must give way to containerisation. Any article which can be damaged when stamped on, or fractured when hit from a dense object, should be given the protection it deserves.
The Jiffy bag concept is the most advanced and most successful packaging system in the world. Its purpose is defeated when dense objects are placed alongside low density objects and then all thrown in a mail sack.
There are four areas of the Post Office I could revolutionise. The first is containerisation. Packing the mail in a box similar to plastic milk crates would enable them to be stacked on top of each other and avoid the weight of a pile of mail bags damaging those on the bottom. With openings in the front of each box, the mail could be added as it is received and avoid a double set of handling.
Most importantly, some guarantee of surety would be restored to everyone sending a gift through the post. Almost without exception, the sender thinks "will it get smashed in transit?"
This is the first and foremost overhaul of the post office. It affects every reader of TE. At more than one stage you will be sending for a kit, posting us a completed kit for assessment, repair or calibration. You would like to think it travels the two directions in relative harmony and doesn't arrive back with a note saying "smashed beyond repair".

CORRECTIONS FOR THE LOGIC DESIGNER BOOK.

A number of very small mistakes have been pointed out for this publication. These do not alter the operation of the unit.

The photo on P 8 shows a .01 capacitor. This should read 0.1mf

On the overlay, the positive lead of the 1mfd electrolytic in the one-shot circuit should be negative. The other hole should be marked positive.

The resistors should be as follows:

1 - 150R
3 - 220R
1 - 270R
5 - 330R
1 - 390R
7 - 470R
2 - 1k
2 - 3k9
8 - 10k
1 - 22k
2 - 47k
4 - 100k

A new addition to our advertisers is THE AUSTRALIAN DIGITAL ELECTRONICS SCHOOL.

We have received hundreds of requests from readers wishing to learn digital electronics via a HOME-STUDY course. The programme covered by the school presupposes only a small basic knowledge of electronics such as being able to identify resistors, reading colour bands, reading capacitor values and identifying the cathode leads of diodes and LEDs. You should also be able to identify all the components we have used in TE projects .

The course seems very good value for money as it contains a number of test papers and question sheets which are sent in for correction. We have already looked over two other courses and these did not get past first base because they did not provide any question sheets for you to send in to your instructor.

For quality and cost, this course is by far the best. You will need to complete the 5 sections of the course to gain its full value.
It uses the latest terminology and is applicable to Australian conditions. Two other courses we investigated were at least 5 years out of date and used overseas terminology and technology.

THe first stage of the course deals with basic requirements and initial digital terms with a simple practical project. In the next sections you will be required to construct a complete digital project and answer a range of questions

The top section of P 36 is incorrect Cut out this corrected version and place it between P 36 and 37.

FINALLY, WHEN USING A CENTRE-TAPPED (2 DIODE) SUPPLY THE PEAK REVERSE VOLTAGE (PIV) ON EACH OF THE TWO DIODES IS TWICE THE PIV FOR THE 4-DIODE BRIDGE RECTIFIER SUPPLY.

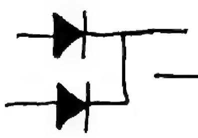
THIS BECOMES A DESIGN CONSIDERATION WHEN THE VOLTAGE IS NEARING THE MAXIMUM PIV RATING OF THE DIODES.

PIV RATING

THE RATING OF A DIODE SUCH AS IN4002 IS GIVEN AS: 100V @ 1AMP. THIS IS ITS FORWARD-VOLTAGE RATING & CONTINUOUS CURRENT RATING. IT HAS A REVERSE-VOLTAGE CAPABILITY OF 120% OR 120V

MOST DIODES CAN WITHSTAND UP TO ABOUT 140% IN THE REVERSE DIRECTION.

USING A 15V TRANSFORMER THE PIV RATING FOR A CENTRE-TAPPED POWER SUPPLY, EACH OF THE 2 DIODES MUST BE RATED AT MORE THAN:



TWICE × 15V × 1·41 = 42·4 VOLTS

FOR A 4-DIODE BRIDGE RECTIFIER, EACH DIODE MUST HAVE A RATING GREATER THAN:

ONCE × 15V × 1·41 = 21·2 VOLTS.

THIS SHOWS THAT THE REVERSE VOLTAGE IS A LOT HIGHER THAN THE (OPERATING) OR OUTPUT VOLTAGE OF THE SUPPLY.

relating to its operation. No additional text books are required and you can refer to past issues of TE for back-up information.

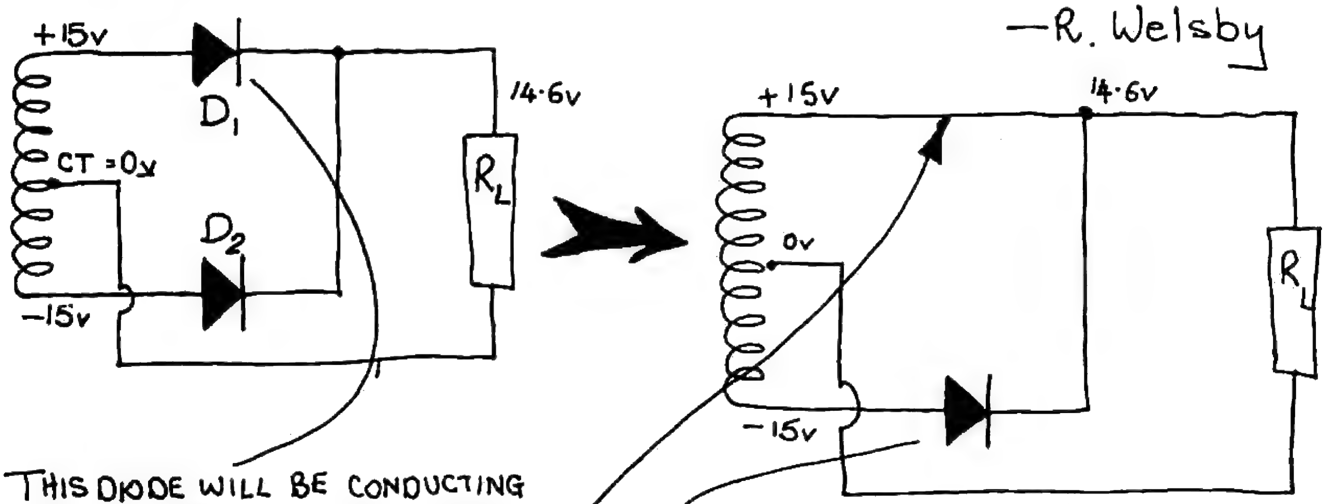
You will see the AUSTRALIAN DIGITAL ELECTRONICS SCHOOL advertisement on P 61 and 62. The Preliminary Test can be photocopied if you don't like cutting up the magazine, but it should be sent in to let them know your commencement level.

PROJECT BOOKS

Understandably, some readers are a little confused with the differing prices of some of our publications. Especially the price of TALKING ELECRONICS increasing from $1.20 to $3.75. Tied in with this is the Project Book series at $3.95.
We have had a couple of readers who cannot quite fathom out the difference between the two. I realise this has not yet been explained and I have taken it to be understood by readers. From the enormous response to the Project Book series, I think most people have interpreted the situation.
For those still uncertain, here's the answer in a nutshell.
Talking Electonics is a publishing venture. We generate all the material for our publications right here on the spot. And it takes a month or so to get all the material together. This also applies to the Project Book series. The first two books have been released, the third book is in the process of arrangement. At the moment we know its broad concept will be a power supply project. The exact final design is still to be arranged. This means books four and five are still on the drawing board and until book three is completed,that's where they will stay. But don't despair, they are guaranteed to be just as popular as the first two releases. We constantly keep coming up with better and better ideas. At times we have to curb our enthusiasm to keep the projects cheap and readily buildable.
If you like the first two books, you can send for the remaining three books and be assured of getting them as soon as they are printed. Subscribers usually get their copy one or two weeks before the shops due to the distribution delays and delays with attaching the PC boards.
We produce only a limited quantity of the Project Books and once they run out, will be deleated from the list of publications. Their life in the shops is also limited as most of the technical schools are now suggesting their purchase.
To save constant looking on the news agents shelves for a new release, you can remove the frustration by placing an order with your newsagent or through us. We don't date any of the publications for the very reason that they are undateable. So you have no prior warning as to when they will be appearing.

HOW TWICE THE VOLTAGE APPEARS ON EACH DIODE

—R. Welsby



THIS DIODE WILL BE CONDUCTING AND WILL HAVE A VOLTAGE DROP OF ·6v ACROSS IT.

THIS VOLTAGE DROP IS SO SMALL WE CAN ALMOST NEGLECT IT WHEN CONSIDERING THE VOLTAGE ACROSS THE LOWER DIODE.

THE VOLTAGE ON THIS DIODE IS +14·6v ON ONE END AND -15v ON THE OTHER. THUS IT "SEES" OR HAS TO "WITHSTAND" 29·4 VOLTS AND THIS IS IN THE REVERSE DIRECTION TO ITS NORMAL OPERATION.

THE SAME SITUATION APPLIES WHEN THE TRANFORMER VOLTAGE REVERSES DIRECTION AND THE TOP WINDING BECOMES -15v.
IN THIS CASE THE TOP DIODE WILL BE REVERSE BIASED TO 29·4 VOLTS.

LETTERS...

The majority of disgruntled readers have had their say. After the first wave of dissatisfied readers, almost all the letters we are now receiving are coming from the more appreciative sector. They are saying things like: ...and at $3.75, the magazine is excellent value. R J Foster, 2122.
Or from T Ryan, 3550: I like the idea of attaching the PC board to the magazine, it provides extra incentive to get moving and do some construction. As the magazine comes out every two months, I do not think the price of $3.75 is all that bad. I look forward to further issues and intend to keep buying it.

When you embark on a new venture, you expect to get a percentage of unfavourable comment and should also be prepared for a high downturn in sales.
Fortunately this did not eventuate. Much to the disappointment of six readers. They thought the inclusion of the PC boards would sound the death knoll of TE and they vowed never to buy another issue. But our sales did not decline and in fact we picked up a small percentage of new readers. As I expected, the inclusion of a printed circuit board attracted the attention of quite a number of browsers. This, in itself, has proven to be very successful.
Readers living on the outskirts of cities or even in the remoter areas have found the printed circuit board idea to be an accelerating factor in getting into construction. This is evidenced by the increase in mail orders. They have increased by over 300%. Many readers have ordered every kit we make. This shows the enormous acceptance of the magazine and its approach to learning.

I can't say we will be including PC's on all future issues, but the ideas for PC's have not run out yet!

Enough of my views, here are a few letters from readers:

When playing with the HANGMAN, I found LEDs 14 and 15 very difficult to illuminate. When they are illuminated, they tend to fade out very quickly as though there is a leakage in the circuit. Can you explain this?

M. Jackson,
Brooklyn Park, 5032.

Your project is working perfectly. You have just experienced one of the most important lessons with transistors. They require a current to be fed into their base circuit which is equal to about 1% of the load current, to keep them turned on.

For this discussion, Q1 is the transistor we are driving and the 470 mfd electrolytic is the capacitor we are using to supply the current (voltage).
As you have found out by playing the game, it is more difficult to illuminate the last few LEDs, than the first LEDs in the staircase. This is due to the charging characteristic of the electrolytic. It is easy to charge the electrolytic to 1,2, or 3 volts and the first set of LEDs come on quite easily. As the electrolytic charges to 8, 9, 10 volts, it requires a lot more touches of the TOUCH SWITCH to increase the charge by 1 volt. This is due to the small difference between the charging voltage and the voltage on the electrolytic.
As the voltage on the electrolytic increases from 9 to 10 volts, the emitter-follower transistor Q1 enables LEDs 14 and 15 to be illuminated and thus it requires more current into its base circuit. It takes this current from our charging pulses and thus it makes it more difficult for us to charge the electrolytic and also supply the base with current. When we stop "pumping up" the LEDs, the top LEDs begin to die down as the electrolytic loses its charge.

I recently built the HANGMAN project and found that the shutdown transistor Q13 would fail after two or three discharges of the 470mfd electrolytic. I was wondering if you could explain why this is happening. I have had to replace the transistor 3 times.

R. Wells,
Lithgow, 2790.

We examined all prototype models and found that none of them suffered from the fault you described. In fact we could not even destroy the transistor by placing a shorting link across the SHUT DOWN wires.
It seems you may have a batch of weak transistors or you may have shorted across the shut down wires with a shorting link when supplying the project from a power supply. Under these conditions the transistor will provide a short circuit to the voltage doubling arrangement by providing a short via the base-emitter circuit. Normally the resistance of your finger would limit the current and progressively turn the transistor on to discharge the electrolytic.

I would like to compliment you on the 4 amp power supply which I am constructing. However there is one thing holding up the contruction. I would like to know how to tell the primary from the secondary on the 18v 6amp transformer (DS cat M 2000) as there are no markings on it.

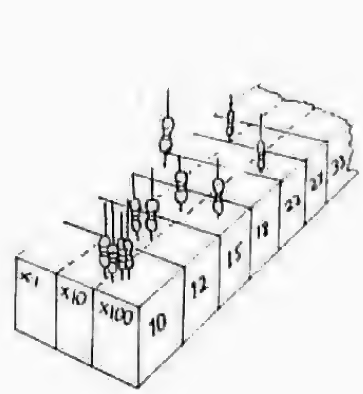
D. Bayne,
Clifton Hill, 3068.

For this type of transformer, or any any others with a high output current, the secondary winding, (supplying the 18v) will be the THICK WIRE. The terminations will be flying lead so that you can connect the leads directly to the bridge rectifiers and thus remove the need for any terminal blocks or strips.

STORING RESISTORS

The accompanying diagram is my design for storing resistors and capacitors. It is cheap as everyone has plenty of foam styrene lying around. It can be hinged together as shown in the small sketch to make storage easier. When you open it, the whole range is visible and it is simple to remove or replace a component. I prefer this system to separate drawers or bags.

R J Ohlson,
3152.



I read your magazine with a great deal of interest and make some of the projects, but would like to see more projects on "VERO BOARD".

R Krueger,
Albany Creek, 4035.

Thanks for your note. We know the type of board you mean. It has copper strips running across or down its length and is covered in holes spaced at .1" Unfortunately we have not had much success with this type of board for prototyping. By the time you sit down and cut between the tracks, you have lost your concentration and also a hole in the board. You also have to think ahead before cutting any tracks and this makes it a very slow process. Much better is our MATRIX BOARD 24 x 25 with individual lands. You can build up the circuit as required and no holes are lost in the process. We try to avoid strip-board or the Matrix Board as much as possible as it is very difficult to build onto and for the slight cost-saving, does not produce a project anything like as nice as a PC board with overlay. We gave up copper strip boards before the magazine went into production as a bad form of construction. It is an extremely bad form of instruction as the majority of the copper tracks are unused and are distracting. The layout nearly always has to be governed by the board and this does not suit our projects since most of the readouts are soldered directly to the PC board.

0 - 100 COUNTER

Dear Sir,
I would like to know if I can modify the Percentile Dice on P 26 of issue 7 into a counter capable of counting up to 100.

K R Gregory,
Buderim, 4556.

Yes! This can be done quite simply and quickly. By replacing only a few components the circuit can be turned into a debounced one-shot, enabling the counters to operate from a push button. By comparing this **circuit** with the original, you will see how we have achieved this modification.

The operation of the circuit is as follows:
The switch is connected to transistor Q1 and this transistor is kept ON via the two 10k resistors in the base circuit The operation of the switch will turn this transistor OFF During quiescent (rest) conditions, the voltage on the collector of Q1 will be very near to zero and thus Q2 will be turned OFF since it has no base voltage supplied to it. Its collector voltage will be near rail voltage.

When the push button is pressed, transistor Q1 is turned OFF and its collector voltage rises from zero to rail voltage. This action takes the positive end of the 10mfd electrolytic HIGH and since it is in an uncharged condition, the negative end will attempt to follow too. This will turn ON Q2 and and lower its collector voltage so that the base of Q1 will not receive a turn-on voltage via the two 10k resistors. This shows that the operation of the switch is taken over by the action of Q2 and the switch no longer has any effect.

After a period of time as set by the charging of the electrolytic, the voltage on the base of Q2 falls to a point where it is no longer held turned ON. The circuit then changes state and remains in this condition ready for the closing of the push button. The time delay can be adjusted by altering the value of the electrolytic.
This proceedure will clock the 4026 (IC2) ONE COUNT The circuit is designed to accept up to one hundred counts and will make a very simple counter.

TE CLUB:

These readers have expressed a desire to correspond with other readers. Try your hand at writing. Pick out a local or even a distant address and send a few lines. Just talk about general things and keep to low technical questions. I am sure you will gain a lot if you give it a try.

Paul Cavanagh,
RMB 423, 'Kildare',
Boatharbour, 2480.

Bill Roberts,
20 Sharpie Cres,
Grange, 5022,

Trevor Hein,
20 Mudgee St.,
E. Burwood, 3151.

J Ratcliffe,
1/37 Whiting St.,
Labrador, 4125.

Brian Turner,
74 Queens Rd.,
Katoomba, 2780.

NZ SUPPLIERS:

Magazines and PCB's
BC ELECTRONICS,
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BELFAST,
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PC Boards - ONE-OFFs:
ZERO ELECTRONICS,
Box 7017,
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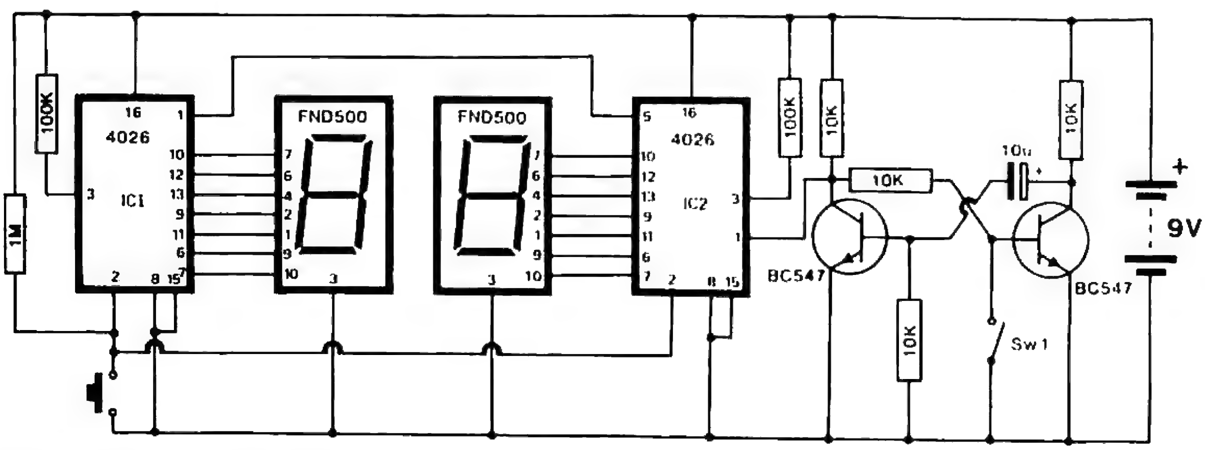
NEW ZEALAND.

DENTRONIC ENTERPRISES,
Box 56195,
DOMINION Rd.,
AUCKLAND 3,
NEW ZEALAND.

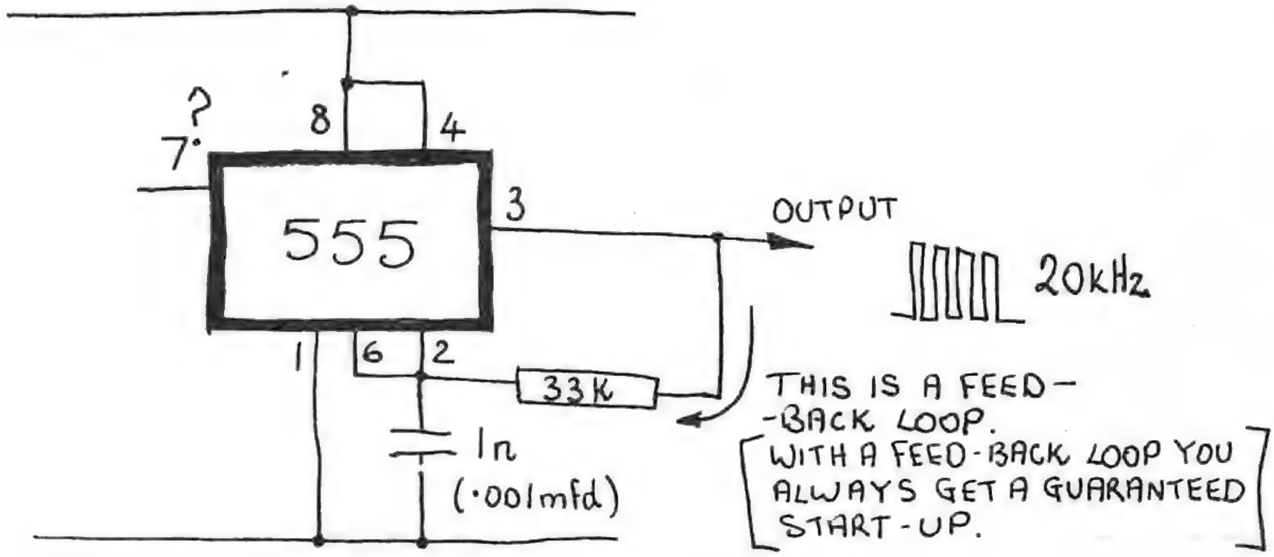
One off boards cost 10c (NZ) per square cm on FIBRE GLASS. Send in your artwork and they will quote for any number of boards.



53

20K Hz Oscillator

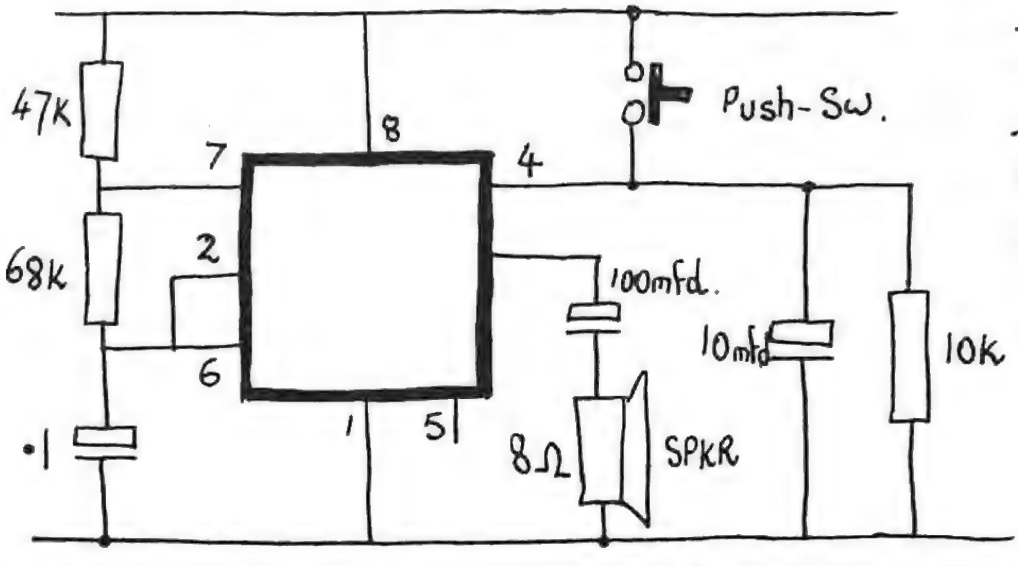
HERE IS AN UNUSUAL-LOOKING CIRCUIT. IT DOES NOT USE PIN 7. THIS ARRANGEMENT IS POSSIBLE SINCE PIN 7 IS ALWAYS IN PHASE WITH PIN 3. SO PIN 3 CAN TAKE ITS PLACE. THE CIRCUIT IS GUARANTEED TO START UP BECAUSE AT THE MOMENT OF TURN-ON, THE CAPACITOR IS UN-CHARGED AND PIN 2 TURNS THE CHIP ON. PIN 3 WILL BE HIGH AND CHARGE THE CAPACITOR VIA THE 33K RESISTOR. WHEN 2/3 RAIL VOLTAGE IS REACHED, THE IC TURNS OFF & THE CAP. DISCHARGES VIA THE 33K TO 1/3 RAIL VOLTAGE. THE CYCLE THEN REPEATS ITSELF.



WHAT HAS HAPPENED TO PIN 7? READ TEXT ABOVE.

Gating the 555

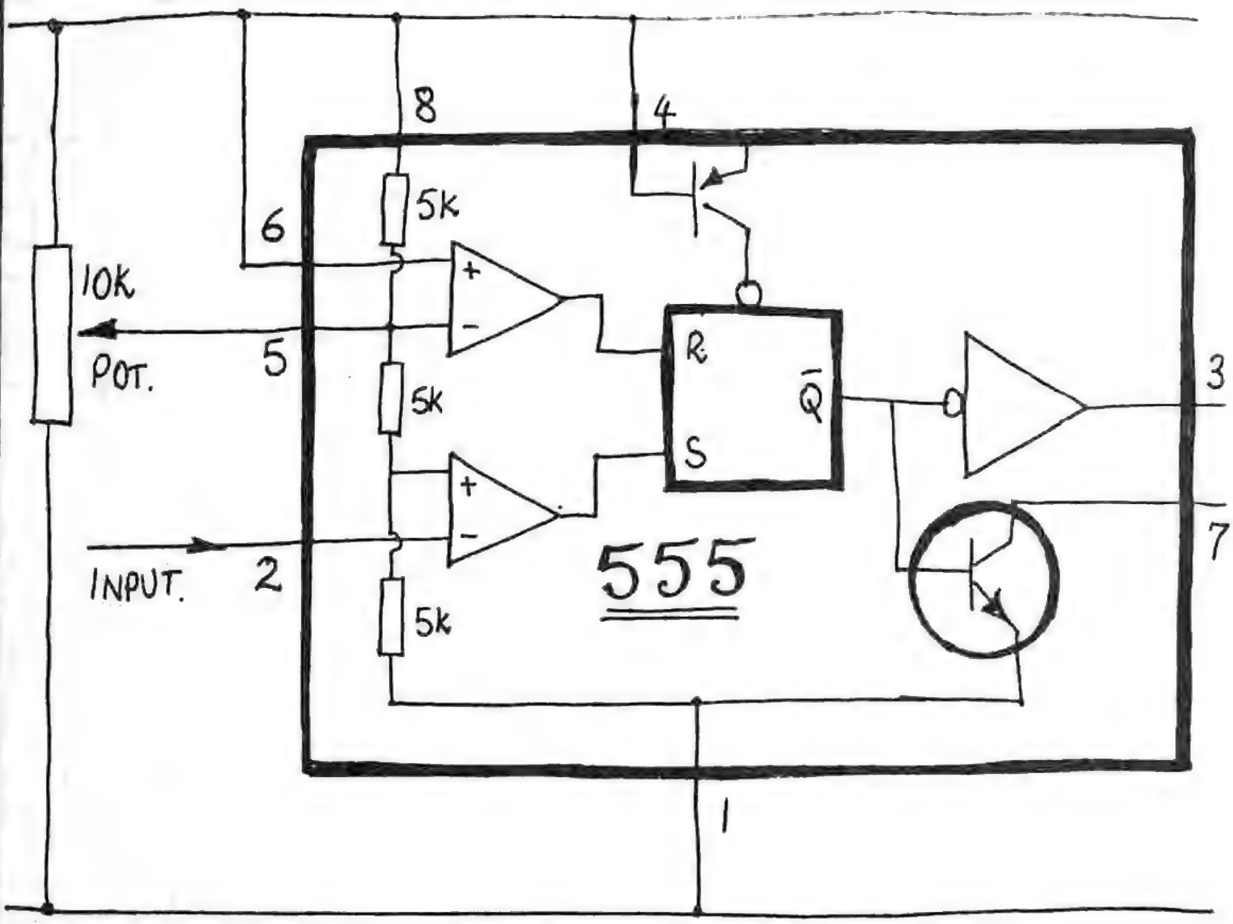
THE 555 CAN BE TURNED ON AND OFF VIA PIN 4. THE CIRCUIT SHOWS AN OSCILLATOR TRIGGERED INTO OPERATION VIA THE PUSH-BUTTON. THE 10mfd ELECTROLYTIC IS CHARGED UP AND WILL KEEP THE CIRCUIT OSCILLATING UNTIL THE ELECTROLYTIC VOLTAGE FALLS TO BELOW 1V. EVEN THOUGH THE OSCILLATOR STOPS, THE 555 CONTINUES TO DRAW CURRENT & THIS CIRCUIT IS NOT SUITABLE FOR BATTERY OPERATION.



54 THE 555 AS A TRIGGER

THE 555 CAN BE USED AS A TRIGGER WHEN CONNECTED AS SHOWN. THE OUTPUTS AT PINS 3 AND 7 ARE NORMALLY HIGH WHEN THE VOLTAGE BEING DETECTED IS BELOW THE THRESHOLD VOLTAGE. THE THRESHOLD RANGE IS BETWEEN 0V & ½ V_{DD}. AS SOON AS THE "SET VOLTAGE" IS EXCEEDED PIN 3 GOES LOW AND CAN SINK 200mA. AT THE SAME TIME PIN 7 SHORTS TO GROUND.

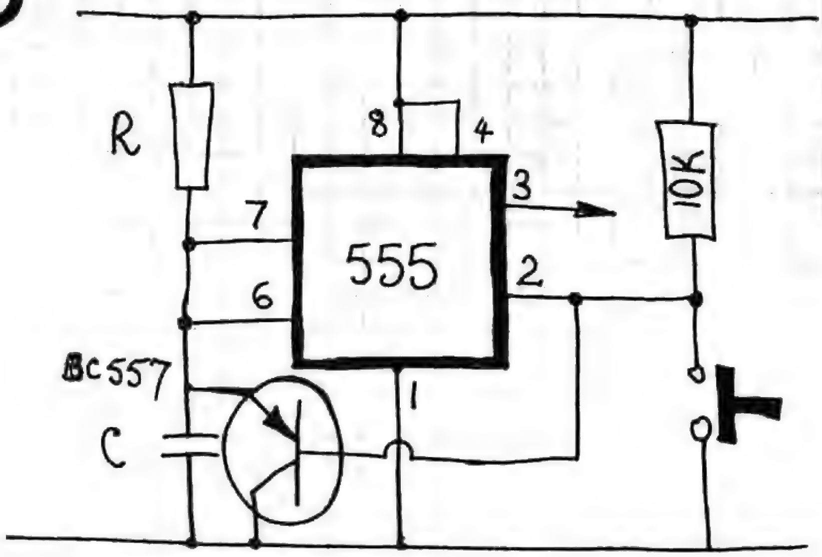
THE INPUT IMPEDANCE AT PIN 2 IS ABOUT 1M & WILL PROVIDE VERY LITTLE LOAD FOR THE CIRCUIT UNDER TEST.



RE-TRIGGERING THE 555

THE 555 ITSELF IS NOT RE-TRIGGERABLE. [RE-TRIGGERABLE MEANS BEING ABLE TO RESET THE TIME-PERIOD TO ZERO WHEN THE TIMER IS PART-WAY THROUGH ITS CYCLE.] THIS THE 555 CANNOT DO. ONCE THE TIMER IS SET INTO OPERATION, IT CANNOT BE RESET. THIS IS DUE TO THE TRIGGER PIN №2 BECOMMING DISCONNECTED INTERNALLY AFTER THE TIMER HAS STARTED. THUS WE MUST PROVIDE RE-TRIGGERING EXTERNALLY. THE CIRCUIT IN THE NEXT BLOCK SHOWS THIS.
THE EXTERNAL TRANSISTOR IS CONNECTED AS AN EMITTER-FOLLOWER. WHEN THE INPUT GOES LOW, THE TRANSISTOR REMOVES THE CHARGE ON THE TIMING CAPACITOR. THIS WILL LEAVE ABOUT 1V ON THE CAPACITOR AND SLIGHTLY REDUCE THE SECOND TIMING CYCLE.

55

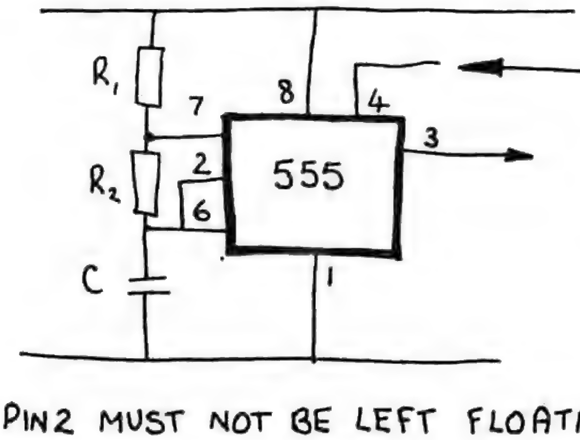


RE-TRIGGERING THE 555.

EVERY TIME THE PUSH BUTTON IS PRESSED WITHIN THE TIMING CYCLE, THE CAPACITOR WILL BE DISCHARGED. THE 555 WILL NOT CHANGE STATE DURING THIS RE-TRIGGERING SINCE PIN 6 IS NEVER ALLOWED TO REACH $2/3\,V_{DD}$. IF THE PUSH-BUTTON IS KEPT PRESSED, THE CHARGING CURRENT WILL FLOW TO EARTH.

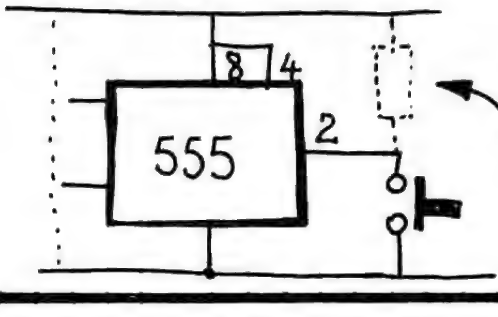
POINTS FOR GOOD TIMER DESIGN

1 WHEN MAKING A LONG-DURATION TIMER, OR IN FACT ANY CIRCUIT, PIN 4 MUST NOT BE LEFT OPEN OR NON-CONNECTED. THIS PIN HAS A VERY HIGH IMPEDANCE AND WILL TURN THE CIRCUIT ON OR OFF IF IT PICKS UP RANDOM NOISE. IT SHOULD BE CONNECTED TO V_{DD} TO KEEP THE CIRCUIT TURNED ON.



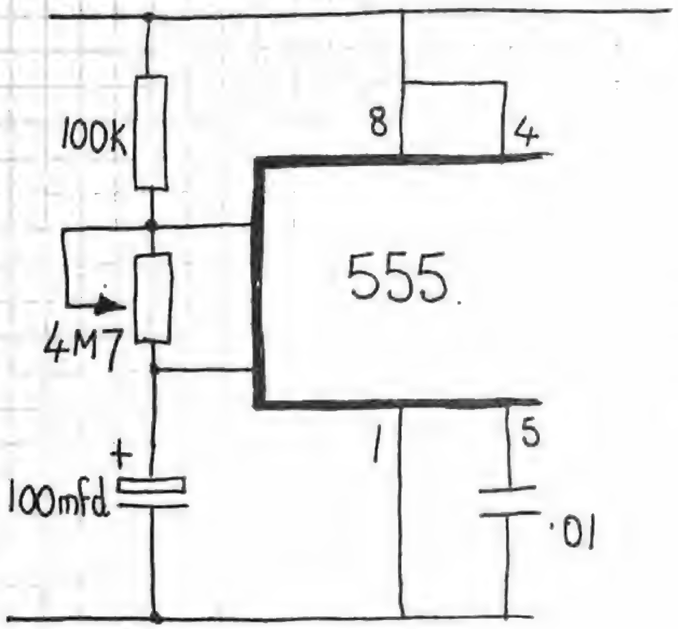
DON'T LEAVE THIS PIN FLOATING. IT WILL UPSET THE OSCILLATOR BY TURNING THE CHIP ON AND OFF

2 PIN 2 MUST NOT BE LEFT FLOATING AS SHOWN IN THE LOWER DIAGRAM.



IT IS A HIGH-IMPEDANCE INPUT AND WILL PICK UP NOISE PULSES AS SMALL AS YOUR FINGER TOUCHING A PIECE OF INSULATED WIRE! IN THIS CIRCUIT, PIN 2 SHOULD BE CONNED TO THE SUPPLY RAIL VIA A RESISTOR, IN THE RANGE 10K TO 100K TO KEEP THE INPUT HIGH.

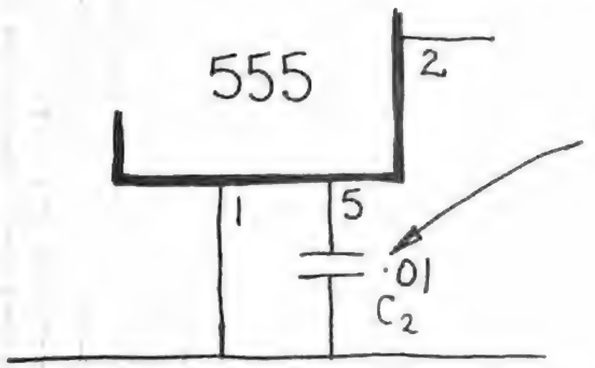
56 3 LONG DURATION TIMING DEPENDS ON THE VALUE OF R & C. BEING VERY HIGH VALUES. IN THE LIMIT, THE LEAKAGE OF THE ELECTROLYTIC BEGINS TO EQUAL THE CHARGING CURRENT AND THE VOLTAGE ON PIN 6 NEVER REACHES $2/3\,V_{DD}$.



THE MAXIMUM VALUES ARE SHOWN IN THE CIRCUIT DIAGRAM. THE 4M7 SHOULD BE MADE VARIABLE TO DETERMINE THE MAX. TIME DELAY & SHOULD THEN BE REDUCED TO ALOW FOR LEAKAGE DURING AGING OF THE CAPACITOR.

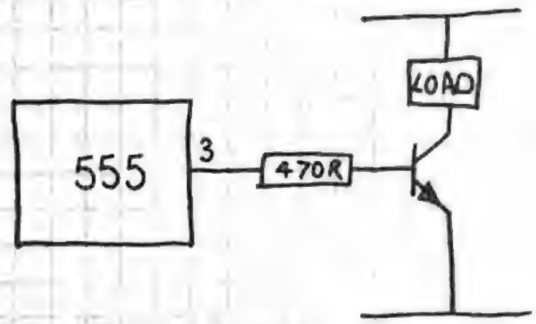
FOR EXTREME RELIABILITY THE CAPACITOR SHOULD BE TANTALUM OR LOW-LOSS ELECTROLYTIC.

4 IN A ONE-SHOT CIRCUIT OR A LONG DURATION TIMER, PIN 5 MUST BE BY-PASSED WITH A ·01 MFD CAPACITOR. THIS WILL PREVENT THE CIRCUIT SELF-OSCILLATING IF THE PUSH-BUTTON IS STILL BEING PRESSED WHEN THE CIRCUIT HAS COMPLETED ITS CYCLE.

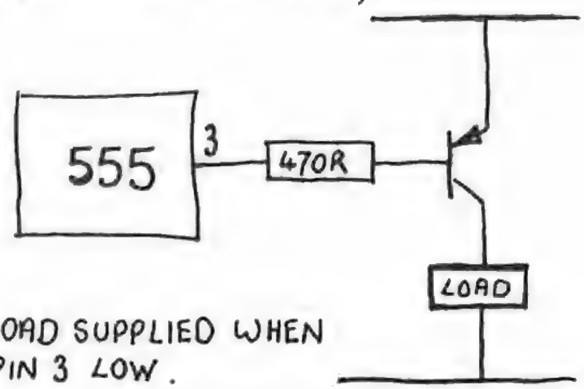


C_2 CAN MAKE A SURPRISING DIFFERENCE TO THE OPERATION OF A CIRCUIT.

5. INCREASING THE DRIVING CURRENT. A 555 WILL DELIVER 200mA (i.e. SOURCE 200mA) OR ALLOW 200mA TO FLOW TO DECK (i.e. SINK 200mA) THIS CAN BE INCREASED TO 2AMP BY ADDING A BUFFER TRANSISTOR CONNECTED AS A GROUNDED EMITTER (COMMON EMITTER)



LOAD SUPPLIED WHEN PIN 3 HIGH.

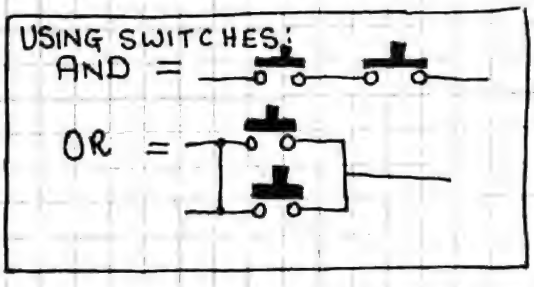


LOAD SUPPLIED WHEN PIN 3 LOW.

DESIGNING WITH DIODES

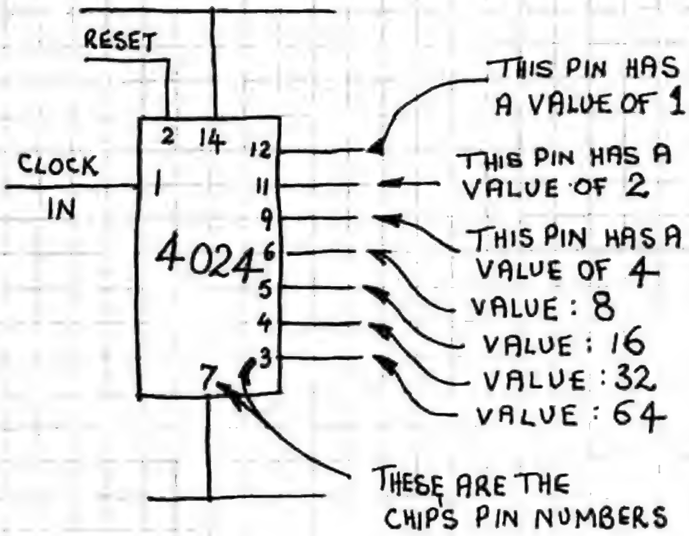
USING ONLY DIODES, 2 BUILDING BLOCKS CAN BE CREATED.

THESE ARE: (1) THE AND GATE
(2) THE OR GATE



THE AND GATE

IN ELECTRONICS, WE NEED AN AND GATE FOR MANY OPERATIONS: — COMBINING OPERATIONS. WHEN TWO OR MORE HIGH SIGNALS ARE PRESENTED TO AN AND GATE ITS OUTPUT GOES HIGH.
TAKE THE EXAMPLE OF A 4024 BINARY COUNTER.



THE COUNTER HAS 7 OUTPUTS WITH EACH PIN HAVING A VALUE AS SHOWN. FOR VALUES SUCH AS 1, 2, 4, 8, 16, 32 OR 64 WE NEED ONLY CONNECT TO THE APPROPRIATE PIN & THE PROBLEM IS SOLVED.

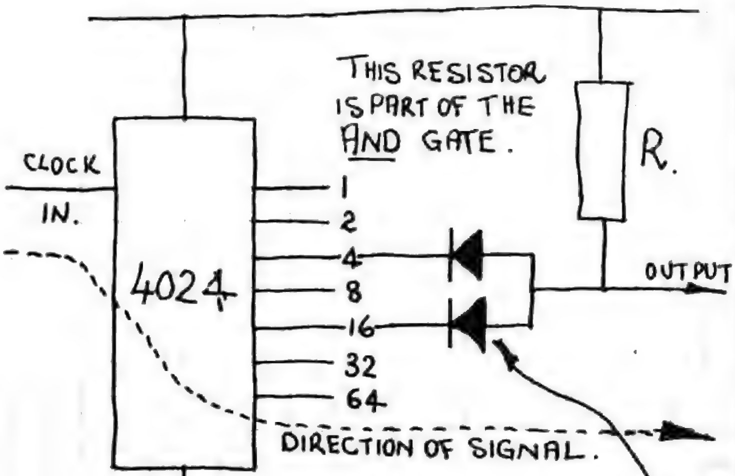
BUT SUPPOSE WE NEED A READOUT OF 20?

THIS CANNOT BE ACHIEVED WITH ONLY ONE OUTPUT PIN SO WE MUST COMBINE 2 OR MORE OUTPUTS.

FOR AN OUTPUT OF 20:
SELECT 16 + 4 (PINS 5 & 9)

WHEN BOTH OF THESE OUTPUTS ARE HIGH AT THE SAME TIME - THE READOUT WILL BE 20. TO ACHIEVE THIS, THEY MUST BE COMBINED TOGETHER. CONNECTING THEM TOGETHER DIRECTLY WILL CREATE A SHORT-CIRCUIT AND DAMAGE THE CHIP AS ONE OUTPUT WILL BE HIGH AT CERTAIN TIMES IN THE COUNTING SEQUENCE WHILE THE OTHER OUTPUT WILL BE LOW.

THE ONLY SOLUTION IS TO CONNECT THEM VIA AN AND GATE.

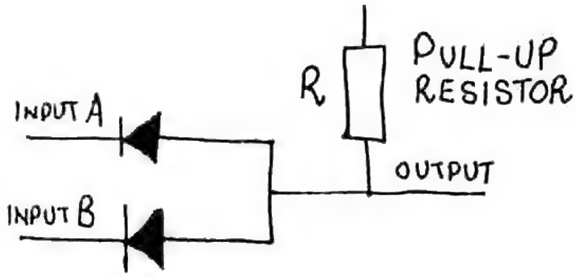


A 2-INPUT AND GATE

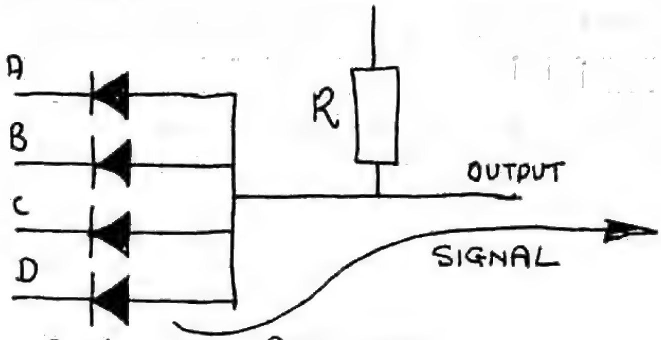
DON'T GO BY THE ARROWS ON THE DIODES WHEN CONSIDERING SIGNAL DIRECTION THE ARROW SIMPLY INDICATES THE CATHODE!

THE AND GATE SECRET.

THE VOLTAGE (AND CURRENT) FEEDING THE OUTPUT FROM AN AND GATE DOES NOT COME FROM THE INPUT VOLTAGES. IT COMES FROM THE PULL-UP RESISTOR R. (THE VALUE OF R IS DETERMINED BY THE CURRENT REQUIREMENT OF THE OUTPUT) THE INPUT VOLTAGES MERELY ALLOWS THE RESISTOR TO PULL THE OUTPUT FROM LOW TO HIGH.



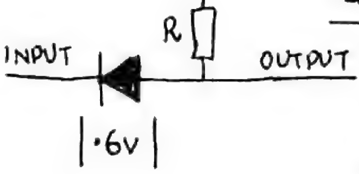
A 2-INPUT AND GATE.



A 4-INPUT AND GATE

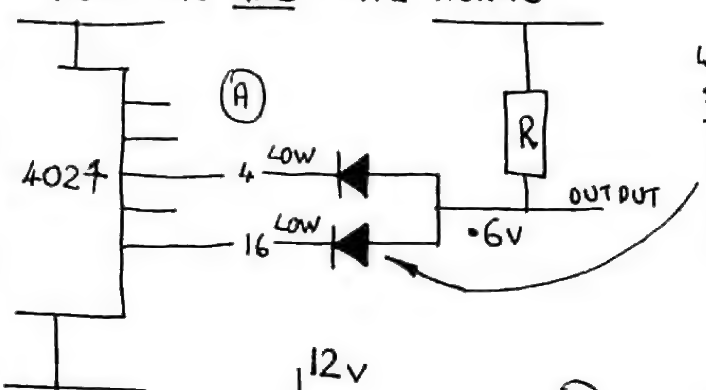
TO IDENTIFY AN AND GATE — LOOK FOR THE DIRECTION OF THE DIODES AND ALSO THE DIRECTION OF THE SIGNAL

A POINT TO NOTE: THE DIODES IN AN AND GATE ARE IN REVERSE FOR THE SIGNAL & THE SIGNAL AT THE INPUT DOES NOT PASS THROUGH THEM. — SO HOW DOES IT WORK? FOLLOW THIS ....



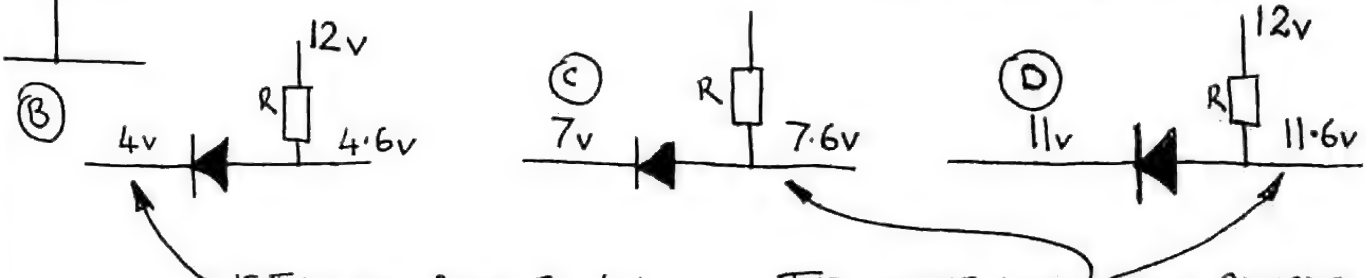
A SIMPLE ANALOGY: I (THE INPUT) SAY THAT YOU (THE OUTPUT) CAN SAVE EXACTLY \$100 MORE (·6v) THAN ME. I DO NOT GIVE YOU THE \$100 YOU SUPPLY THE MONEY YOURSELF (VIA R) YOU ARE SELF-CONTAINED BUT TIED TO MY SAVINGS BY A FIXED AMOUNT (·6v).

HOW THE AND GATE WORKS



WHEN A DIODE IS PLACED IN A CIRCUIT AS SHOWN, ·6v WILL BE DROPPED ACROSS THE DIODE AND THUS THE OUTPUT WILL BE AT ·6v

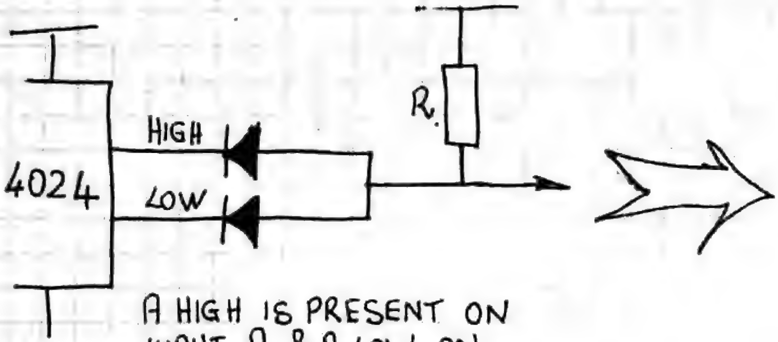
A → D SHOWS HOW "R" PULLS THE OUTPUT HIGHER AS ALLOWED BY THE INPUT VOLTAGE.



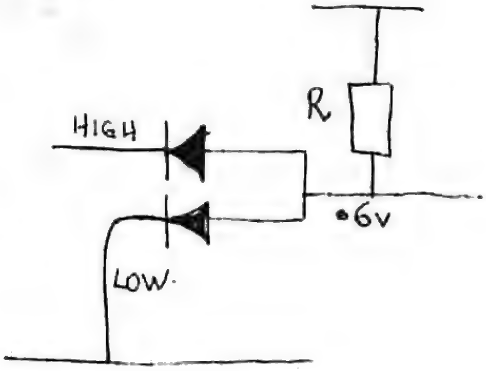
IF THIS END RISES TO 4V, THE OUTPUT WILL BE 4·6v

THE OUTPUT LINE WILL ALWAYS BE ·6v HIGHER THAN THE INPUT.

HOW THE AND GATE WORKS.

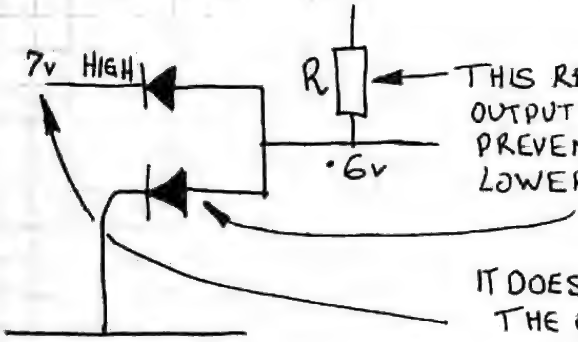


A HIGH IS PRESENT ON INPUT A & A LOW ON INPUT B.



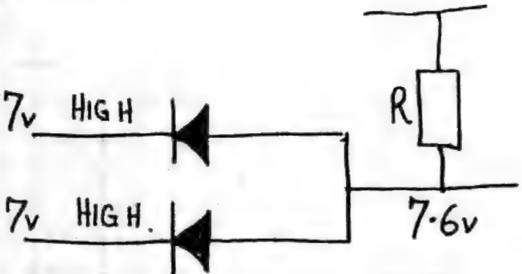
SINCE A LOW IS PRESENT ON THE LOWER DIODE WE CAN CONSIDER IT CONNECTED TO EARTH

THE LOWER DIODE WILL BE THE "SHORTING" INFLUENCE ON THE CIRCUIT. IT WILL PREVENT THE OUTPUT RISING ABOVE ·6V, NO MATTER WHAT THE VOLTAGE ON THE CATHODE OF THE TOP DIODE.

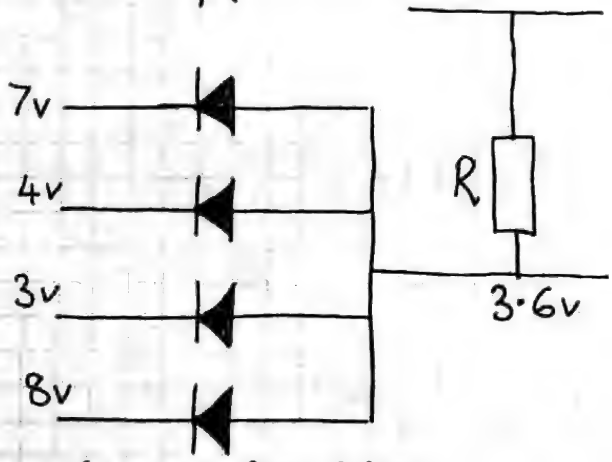


THIS RESISTOR IS TRYING TO PULL THE OUTPUT VOLTAGH HIGH BUT IS BEING PREVENTED FROM DOING SO BY THE LOWER DIODE

IT DOES NOT MATTER IF THIS VOLTAGE IS 5v, 7v OR 10V THE OUTPUT REMAINS LOW.



WHEN A HIGH APPEARS ON BOTH INPUTS THE OUTPUT WILL BE PULLED HIGH BY RESISTOR R. IF 7 VOLTS APPEARS ON BOTH INPUTS THE MAXIMUM OUTPUT VOLTAGE WILL BE 7·6 VOLTS.

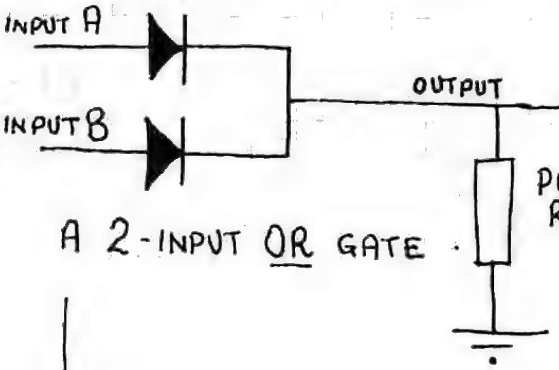


4-INPUT AND GATE.

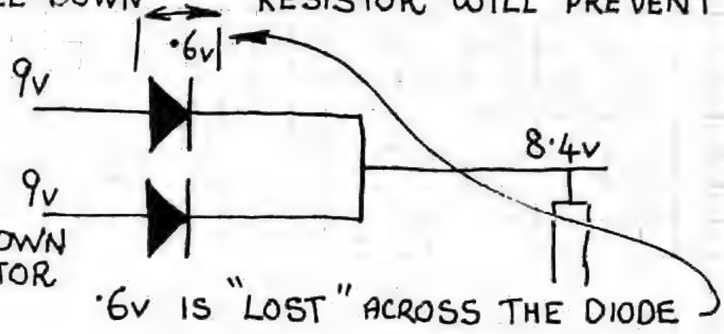
THE SAME REASONING APPLIES TO MULTI-INPUT AND GATES. THE OUTPUT VOLTAGE WILL BE DETERMINED BY THE LOWEST INPUT VOLTAGE. IN THIS EXAMPLE THE 3v LINE WILL ALLOW THE OUTPUT TO RISE TO ONLY 3·6V.

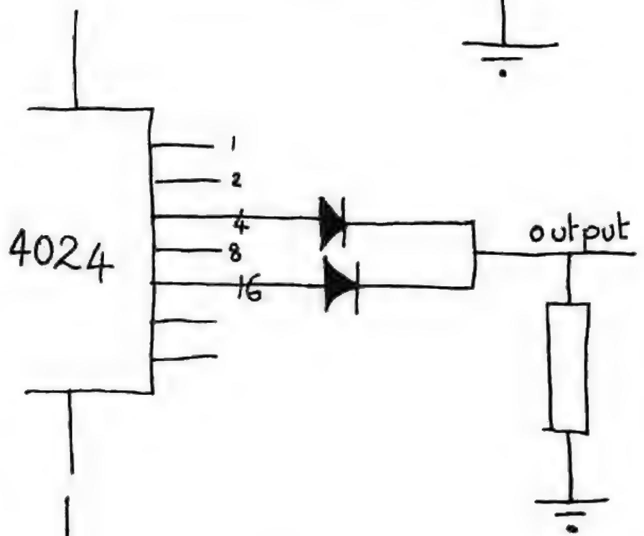
THE OR GATE.

WITH AN OR GATE, THE VOLTAGE (AND CURRENT) IS SUPPLIED BY THE INCOMMING SIGNAL. THUS A PULL-UP RESISTOR IS NOT REQUIRED. (REMEMBER: ·6V IS LOST WHEN PASSING THROUGH AN OR GATE.) BUT A PULL-DOWN RESISTOR WILL PREVENT THE OUTPUT FLOATING.



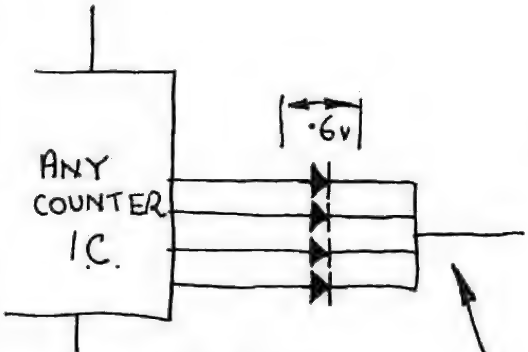
A 2-INPUT OR GATE.





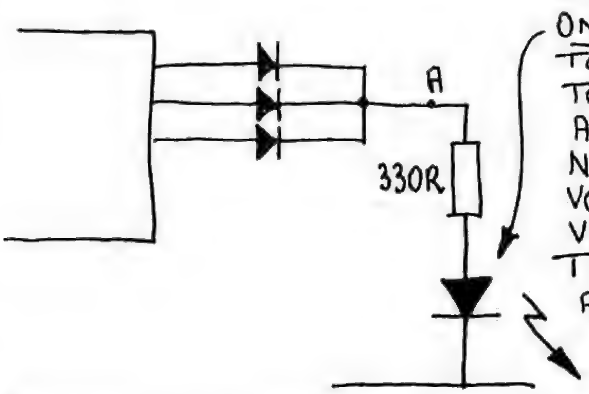
THE OUTPUT OF THIS DIODE OR GATE WILL GO HIGH WHEN "4" IS HIGH. IT WILL ALSO BE HIGH WHEN 16 IS HIGH & ALSO WHEN BOTH OUTPUTS ARE HIGH.

IT WORKS LIKE THIS:
WHEN THE TOP DIODE PASSES A HIGH TO THE OUTPUT, THE LOWER DIODE PREVENTS THE HIGH PASSING INTO THE "16" OUTPUT (WHICH WILL BE LOW)



4-INPUT OR GATE

OR GATES CAN BE EXTENDED BY ADDING ADDITIONAL DIODES. THE VOLTAGE DROP IS STILL ·6V AND THE MAXIMUM DRIVE CURRENT DEPENDS UPON THE OUTPUT CURRENT OF THE INTEGRATED CIRCUIT. THIS IS USUALLY ABOUT 10mA MAX. AS MORE OUTPUTS TURN ON, THE CURRENT CAPABILITY WILL INCREASE BUT THIS IS NEVER TAKEN INTO ACCOUNT WHEN DESIGNING.

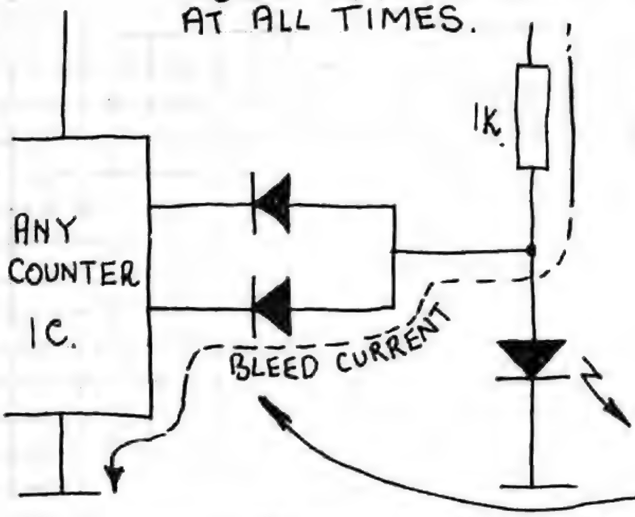


THIS OUTPUT IS ONLY CAPABLE OF DRIVING ONE LED. NOTHING ELSE MUST BE CONNECTED TO THE OUPUT AS POINT A WILL NOT RISE TO A FULL HIGH VALUE WITH AN LED ATTACHED. DEPENDING ON THE CHIP & THE NUMBER OF OUTPUTS DRIVING THE LED, THE VOLTAGE WILL RISE TO BETWEEN 4 AND 8 VOLTS WHEN CONNECTED TO A 9v SUPPLY. THIS WILL BE INSUFFICIENT TO CLOCK ANOTHER IC & SO A BUFFER MUST BE ADDED. THIS IS COVERED IN THE NEXT BLOCK.

ADDING A BUFFER.

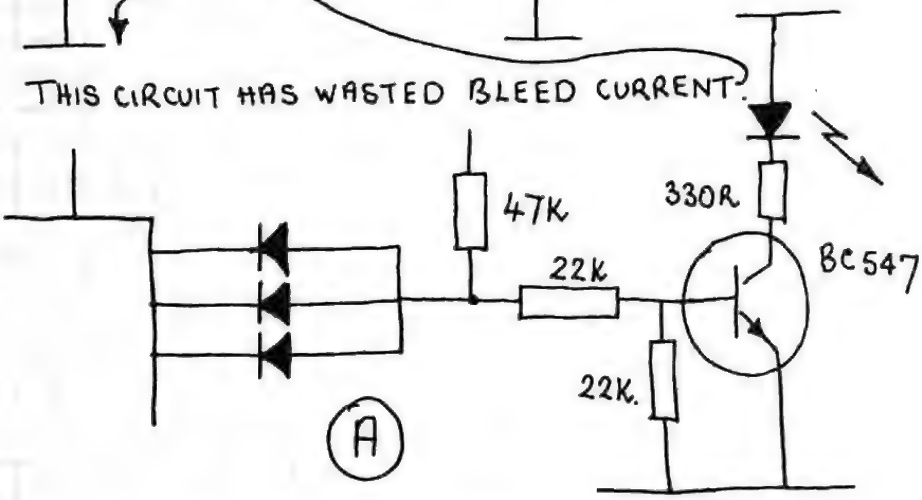
AND GATES & OR GATES HAVE LIMITED DRIVE CAPABILITIES.

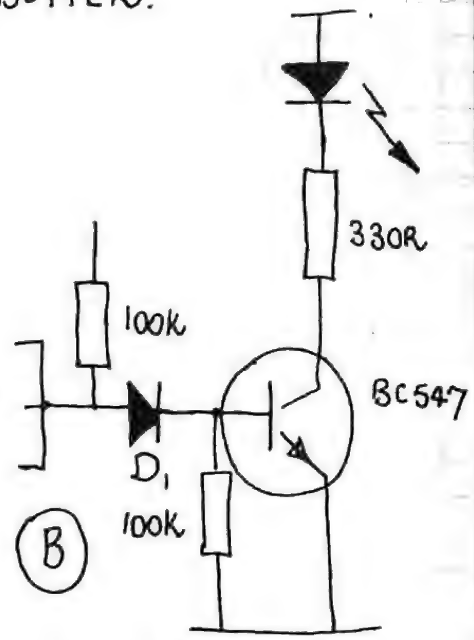
WITH AN AND GATE THE DRIVING CURRENT IS SUPPLIED FROM THE PULL-UP RESISTOR. IF YOU WISH TO DRIVE A LED, TO INDICATE THE HIGH CONDITION, THE PULL-UP RESISTOR WILL NEED TO BE ABOUT 1K. THIS WILL MEAN ABOUT 10mA WILL BE FLOWING AT ALL TIMES.



WHEN THE LED IS NOT ILLUMINATED THE 10mA WILL BE LOST THROUGH THE GATING DIODES. THIS IS WASTEFUL. ESPECIALLY IN BATTERY OPERATED EQUIPMENT. TO REDUCE THE BLEED CURRENT (WASTED CURRENT) WE CAN ADD A TRANSISTOR — CALLED A BUFFER.

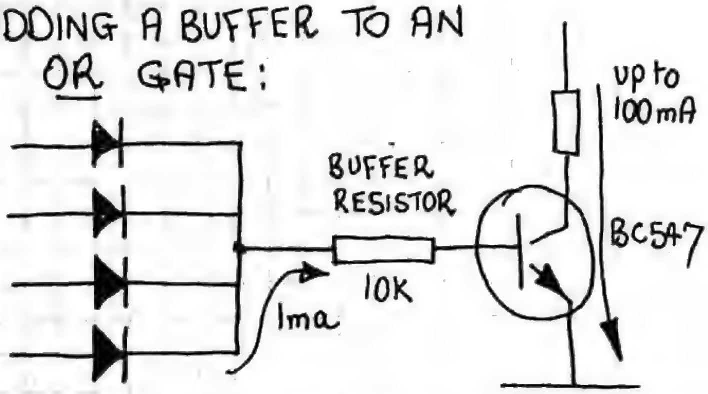
THIS CIRCUIT HAS WASTED BLEED CURRENT.





BY ADDING A BUFFER TRANSISTOR TO AN AND GATE THE BLEED CURRENT CAN BE REDUCED TO 1/100TH. THE OUTPUT OF THE AND GATE WILL BE ·6v MINIMUM AND THIS MUST BE REMOVED OR REDUCED TO PREVENT THE BUFFER TURNING ON. IN DIAGRAM (A) THE 2-22K RESISTORS FORM A VOLTAGE DIVIDER. IN DIAG (B) THE DIODE D_1 COMPLETELY REMOVES THE ·6v AND THUS TURNS THE TRANSISTOR OFF.

ADDING A BUFFER TO AN OR GATE:



THE BUFFER RESISTOR ALLOWS THE OUTPUT OF EACH DIODE TO RISE TO RAIL VOLTAGE WHILE PROTECTING THE BASE FROM RISING ABOVE ·65v. THE OUTPUTS OF THE IC ARE ONLY LIGHTLY LOADED (1mA) AND CAN ALSO DRIVE ANOTHER IC IF NEEDED.

THE TRANSISTOR IS CAPABLE OF DRIVING 100mA LOAD.

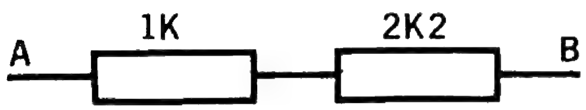
PRELIMINARY TEST
THE AUSTRALIAN DIGITAL ELECTRONICS SCHOOL
Box 334, Moorabbin, Victoria, 3189.

This test is sent in with your enrolment form and will serve as a basis to recording your improvement after completing the course. Attempt all questions. There is no time limit. Do not refer to any data books or reference material. This must be a genuine record of your present knowledge.

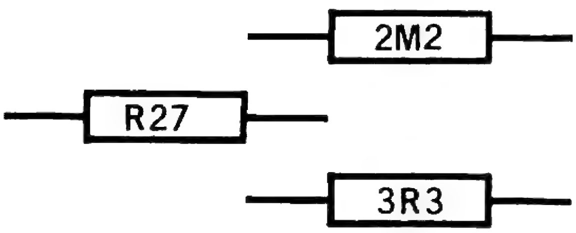
1. Identify these resistors:
(a) red - red - red - silver
(b) black - brown - black - silver
(c) brown - orange - orange
(d) silver - green - brown - black

2. What are the colour bands for these resistors:
(a) 2M2
(b) 4k7
(c) 33R
(d) R1

3. What is the resistance between A&B?



4. What is the value of these resistors?



5. What is the value of these (in mfd):

(a) 10n (b) 100n

6. What is the value of this combination:

7. If the numbers were rubbed off a CD 4017 and a CD 4001, how would you identify the CD 4001?

8. A 555 timer is in a monostable configuration. What is the effect of pin 2 on the output?

9. What is the voltage drop across a silicon diode?

10. Which segments of a 7-segment display would illuminate for the number 5?

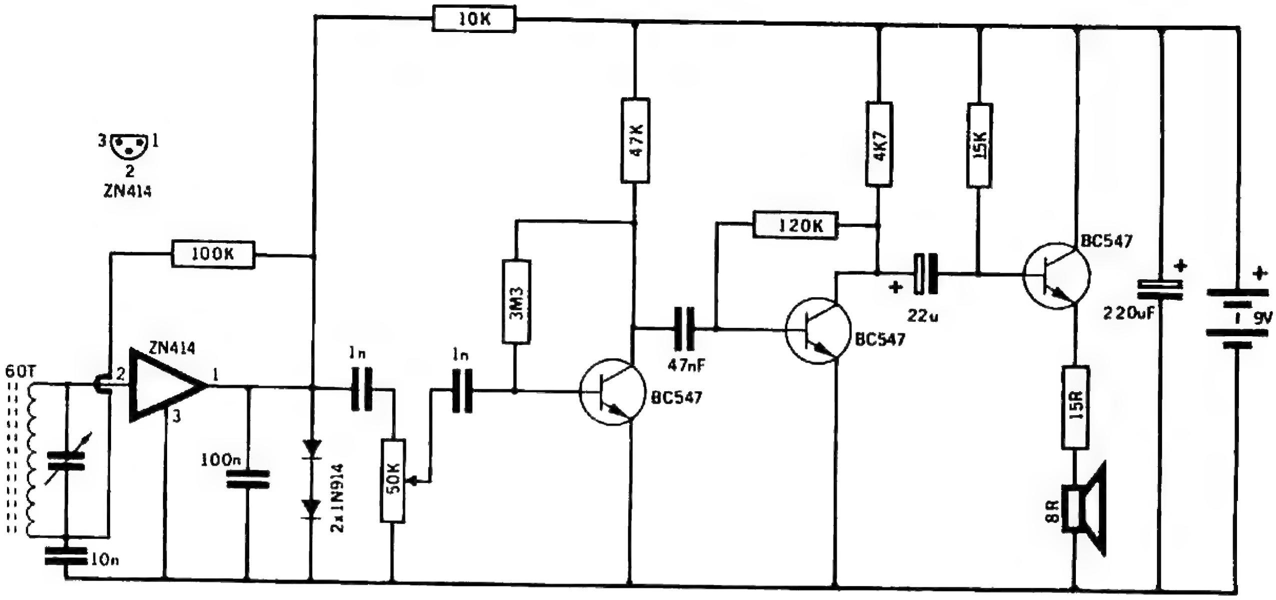
11. What is the binary for:
(a) 32
(b) 61
(c) 87

12. Describe these:
(a) 4011
(b) 7805
(c) CD 4001, 1N 4001.

13. What do these letter stand for:
(a) PCB
(b) MMV
(c) PIV
(d) AMV
(e) RMS
(f) BCD
(g) DIL
(h) DPDT
(i) MFD
(j) LED
(k) RST
(l) GND
(m) 555
(n) CLK

14. Draw a circuit of a 555 operating at about 1kHz:

IC POCKET RADIO



One of my first introductions to electronics came with the construction of a crystal set. Maybe it is seen as a first step to making a pocket radio or could it be the fasination of plucking sounds out of the air?

With me, the ultimate achievement was to produce a radio which could be carried around in a case without the need for an external aerial. Normally receivers such as crystal sets or one transistor radios need a long aerial and earth. It was not until I made a three transistor radio, that the aerial could be reduced to a ferrite rod fitted inside the case. Even then the output was only sufficient to drive an earpiece. I needed to build a 4 transistor circuit before I achieved a really portable set. These endevours spanned a period of years, such was the slow pace of electronics, some 20 years ago.

If you would like to experience the pleasure of making a truly portable radio, this project will be just the thing. Not only is this circuit much simpler than a 6 transistor superhet, it does not have any alignment problems either.

Our circuit is designed around an integrated circuit. This IC contains the complete circuit for a TRF radio and all you need is to provide a FRONT END and a POWER AMPLIFIER to complete a fully fledged portable radio.

This will means you will need only a few extra components to build a radio with similar selectivity and sensitivity to the commercial types.

The great advantage of TRF over superhetrodyne is in the absence of transformers. You do not have to align any of the IF stages and troubleshooting is almost entirely eliminated. The front end is so simple that its operation can be checked with an earpiece connected to the output of the chip. The remainder of the set is a three transistor amplifier using an emitter follower output to drive an 8 ohm speaker directly.

The output stage is class 'A' and while this is not the most economical on power consumption, it is the cheapest and easiest to construct. If you are requiring a more economical output stage, you should consider PUSH-PULL.

For simplicity and performance, you cannot go past this circuit. I am sure you will have lots of enjoyment building it. You can even rob an old transistor radio for some of the major components. This will keep costs down and get the project off the ground quickly.

HOW THE CIRCUIT WORKS

The aerial coil and tuning capacitor form a tuned circuit. This selects only one stations at a time, according to the setting of the tuning capacitor. This signal is picked off the parallel resonant circuit by the ZN 414 radio IC and fed into pin 2. The IC then amplifies this signal and converts it to an audio signal by using a diode detector. The resulting AF appears at the output pin 1. Any unwanted RF components of the signal are filtered out by the 100n capacitor and the AF is fed into a 50k volume control via the 1n capacitor.

The two 1N 914 diodes are designed to provide the IC with about 2v for its operation. These diodes are in their forward voltage mode so that they drop about .65v each, making the voltage supplied to the ZN 414 about 1.3v. The volume control limits the sound level for loud stations and this gives an indication that the circuit will provide fairly good listening level.

The next two audio stages are self basing to save components. The third BC 547 is an emitter follower and is biased in its mid range so that the quiescent current flow is about 20ma. This emitter-follower configuration is able to match the low impedance of the 8R speaker to the output of the second amplifier. A 15R series resistor reduces the standing current of the circuit without having a detrimental effect on the volume.

Our unit was fitted into an old superhet radio case and we achieved about the same volume as a 6 transistor radio.

SENSITIVITY AND SELECTIVITY

Two terms which require a little understanding are SENSITIVITY and SELECTIVITY.
These refer to the front end of a radio. Although they are different features, they go hand in hand. If a radio is not sensitive, it is usually not selective. For instance, a crystal set is not sensitive (due to the fact that it requires a long aerial and earth) and at the same time it has very poor selectivity.

But you can get a highly selective radio which is not sensitive, as is the case with most pocket radios.

Sensitivity is the feature which enables a radio to pick up very weak signals while keeping the background noise to a minimum. In technical terms, it is the minimum input signal required to produce a specified output signal into the audio amplifier. This is usually specified in millivolts however more sensitive radios are able to detect microvolt signals. This may be clearer to understand if we say that radios do not create any sounds. They merely pick up a signal from the airwaves and amplify it. A radio can be thought of as an amplified crystal set.

Using this similarity, you can see the radio must rely entirely on the incomming signal to resonate (cause to oscillate) the circuit made up of the aerial coil and the tuning capacitor. It only takes a few microvolts to resonate a tuned circuit providing you are not loading it. By loading the circuit we mean connecting a probe or other device to detect the frequency at which it is oscillating. This probe tends to kill the oscillations and this limits the radios sensitivity.

It takes only a few microvolts to resonate a tuned circuit so to create a sensitive radio we must make the aerial coil as large as possible with either a long ferrite rod or add a length of aerial wire to the input. If we load this aerial circuit very lightly, we create a highly selective situation and the set will be capable of picking up interstate or overseas stations while rejecting local stations.

Selectivity is the ability of a radio to tune in a particular station and reject all other stations. This is a very important feature for a pocket radio. Most often the listener requires the radio to pick up all the local stations without any interference, even though adjacent stations may be very close on the dial and may even have a higher signal strength.

The radio may not be very sensitive as it is not required to pick up country or interstate stations, but the selectivity is very important.

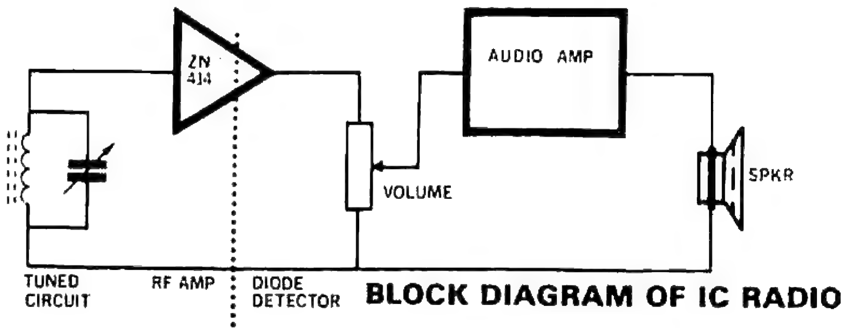
Selectivity is basically the result of lightly loading the aerial circuit so that its Q factor is high and its rejection quality is at a peak.

sistors being operated well within their specifications. The sharpness of tuning of a superhet set is partially due to each stage being transformer coupled and are slug tuned to a particular frequency. This adds to the rejection qualities of the radio and produces good selectivity.

Although these sets are expensive to construct as compared with TRF design, the high reliability and low wage costs in Taiwan and Japan made them very competitive on the world market.

Until now, TRF design was very cumbersome and tricky to get fully operational into a pocket sized radio. Although it does not require any transformers, and could be physically fitted into a smaller case, the major disadvantage was the instability of the circuit. It relies heavily on a feedback loop to create the sensitivity and unless this is carefully controlled, a whistle can be generated. Without any feedback, the sensitivity is very poor. So some degree of compromise is needed.

It was not until the complete front end was put into a sealed package that the TRF design could be considered. In a tiny chip, the



BLOCK DIAGRAM OF IC RADIO

TRF TUNED RADIO FREQUENCY

Radio signals can be detected and amplified by two different means. These are SUPERHETRODYNE and TRF.

There are advantages and disadvantages of each system.
The main reason for superhetrodyne gaining so much popularity was due to its highly stable operation. This comes about in the front end of the radio. The first three transistors are aligned to a set frequency and are required to amplify at only this particular frequecy. This produces a very stable and reliable condition, even when the radio is taken into the sunshine or left out in the cold. The reason for this is due to the tran-

feedback capacitances could be controlled and stray capacitances eliminated and this would make the TRF system practical.

This has been achieved with the ZN 414 radio IC. It looks very similar to a BC 547 transistor as it has only three leads. These are marked EARTH, INPUT and OUTPUT. I refer to them in this order as it corresponds to the COLLECTOR BASE and EMITTER of a BC 547, when you hold the transistor so that the three leads fill the lower half of the case.

The ZN 414 IC comes in two different package styles. A metal can version and a plastic pack. The plastic pack has three in-line leads and by holding the case with the

flat at the top, the leads are: EARTH, INPUT and OUTPUT. The matal can version has a tag so that when holding the device with the tag on the right hand side, the leads are: EARTH, INPUT and OUTPUT.
Don't ask me why they chose this unusual identification arrangement.

Now that we have a good RADIO FREQUENCY amplifier such as the ZN 414, the only other components required to make a TRF radio are:
1. An Audio Amplifier
2. An Aerial Circuit

THE AERIAL CIRCUIT

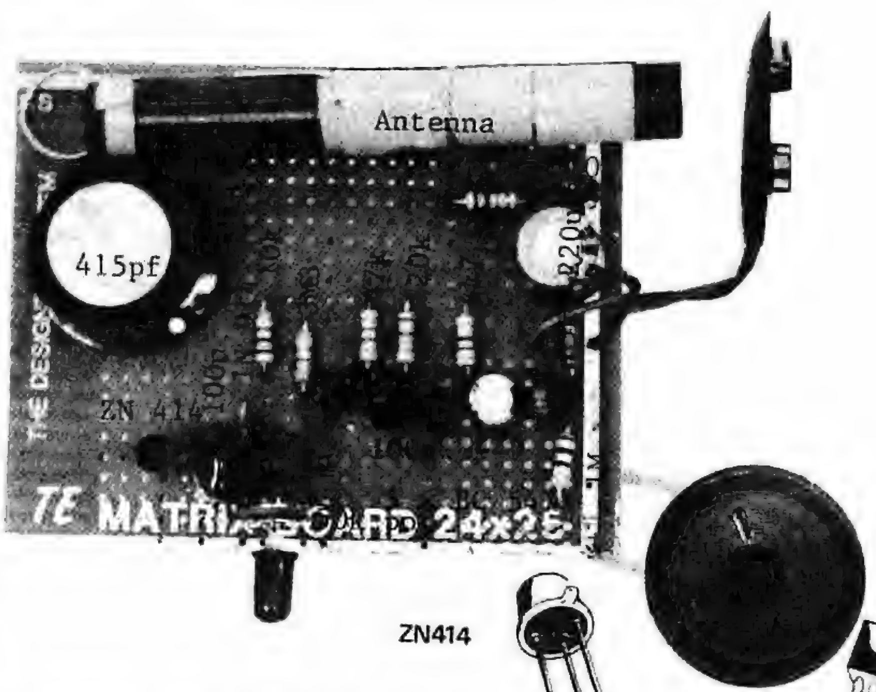
The aerial circuit is very important in a TRF design because the radio chip is only capable of amplifying the signal it picks off this circuit. It does not have any further selective or rejective qualities as in the superhetrodyne circuit containing IF transformers.

The selectivity of a TRF set revolves around the aerial circuit. This circuit consists of only two components. The aerial coil and the tuning capacitor. Because these are so important, we will look into their features a little more closely.

The aerial coil consists of a winding of special wire. This wire is called LITZ and consists of a number of strands of very fine enamelled wire, twisted together and covered in cotton. This type of wire has a lower resistance than a single strand due to the fact that the current tends to flow through the outer layers of a conductor at high frequencies. Litz wire has increased outer layers and thus the effective resistance is reduced.

The ferrite slab has the effect of concentrating and storing magnetic flux and thus it increases the effective inductance of the coil. In fact the actual positioning of the coil on the slab is important and by moving the coil along the slab, the gain of the circuit will be affected. The shape of the slab is also important. A flat slab is more effective than a round rod for the same cross section. The coil should be positioned on the slab so that about ½ to 1 cm of rod protrudes from the end of the winding. The coil is not positioned in the middle of the slab as you would think.

The only other component in the aerial circuit is the tuning



ZN414

3 2 1

YS414

3 2 1

capacitor. This is placed across the coil to create a parallel tuned circuit. Now the theory behind a parallel tuned circuit is very complex and a couple of interesting features are produced by such a circuit. The first is the fact that this circuit will oscillate all by itself as it has the correct values of L and C to pick up the local radio stations. The second interesting point lies in its ability to be unaffected by all the other radio stations which are not of the exact frequency to which it is resonant. The other radio stations are rejected and only one station causes the circuit to resonate.

This parallel resonant circuit has a high Q factor due to the Litz wire and the ferrite slab. The Q factor is a factor-of-merit which primarily determines the sharpness of resonance. This factor can be as high as 500 for a parallel tuned circuit and is the ratio of reactance of the coil to its resistance. These figures apply to an unoaded circuit but this is of no practical use. We must be able to pick off the frequency of resonance and amplify it. After all, this is the radio station we wish to hear. By tapping into the tuned circuit we reduce its Q factor enormously, possibly down to 5 or 10 and so this pick-off signal must be as small as possible. Only with the advent of modern transitors, has this been possible. These transistors require very small input current and will load the circuit very little. This is the ideal situation as we wish to keep the

PARTS LIST

1 - 4k7
1 - 10k
1 - 15k
1 - 47k
1 - 100k
1 - 120k
1 - 1M
1 - 3M3

2 - 1n 100v greencap
1 - 10n 100v
1 - 47n
1 - 100n

1 - 22mfd electrolytic
1 - 220mfd electrolytic

3 - BC 547 transistors
1 - ZN 414 Radio IC or YS 414

2 - 1N 914 diodes
1 - 50k mini trim pot
1 - 8R speaker
1 - 415pf tuning capacitor
1 - knob to suit
1 - ferrite rod and coil
1 - battery snap
1 - 24 x 25 Matrix Board

high selectivity of the circuit intact. The ZN 414 fulfills this condition. It detects the signal at the top of the tuned circuit and amplifies it within the chip. The 10n capacitor provides an earthy end for the tuned circuit while still allowing the front end to be DC controlled by the 100k feedback resistor. The chip then converts the RF to AF via a diode demodulator to provide an audio signal of about 30mV peak-peak.

CONSTRUCTION

We have decided to construct this project on matrix board. This is mainly due the varying sized components which will be used by constructors.
Some of the components such as the loopstick antenna (ferrite rod or ferrite slab antenna) will be taken from an old radio. The same will be true for the tuning capacitor and dial. These are virtually unobtainable in component shops at the moment. This is possibly due to the dwindling need for radio components. In any case, an old transistor radio can always be found in an op shop or supermarket for under $5 and you can then use the case and speaker.

The object of the project is not to produce a transistor radio at a price below the commercial unit, it is to get the experience of making a portable radio from scratch.

The first stage is to mount the tuning capacitor and slab antenna. You will need to drill a fairly large hole in the PC board to take the tuning capacitor shaft and two smaller holes for the fixing screws The antenna should be mounted near the tuning capacitor, leaving a small gap between the two units to prevent interference. Do not use copper wire around the slab antenna to hold it in position as this could produce a shorted turn and reduce the sensitivity of the antenna enormously. Use plastic string or plastic standoffs. If the antenna coil has two windings, you should remove the smaller winding to prevent any mistakes when wiring up the circuit.

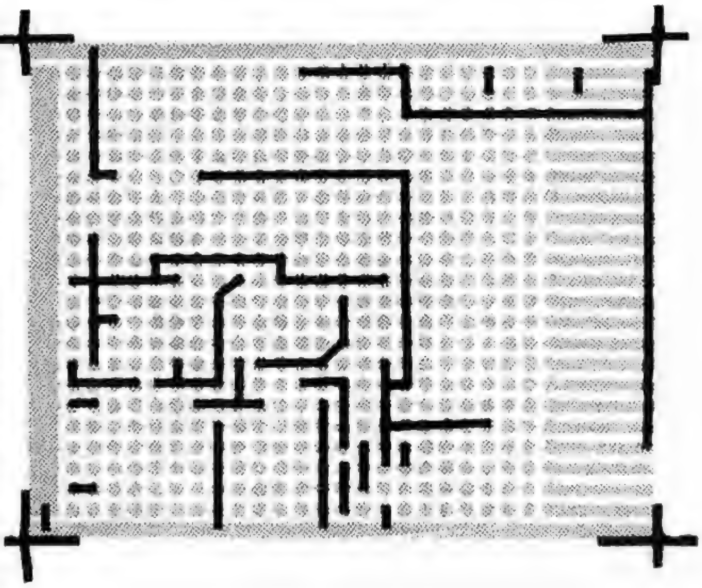
The radio IC is the next component to be fitted and it should be correctly identified before fitting. See the diagram to locate pins 1, 2 and 3.

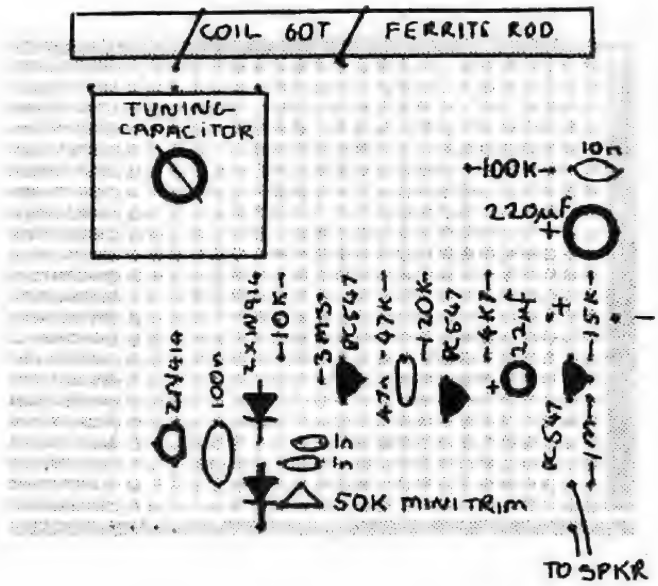
You can use the layout for the parts as per our photo, however it would be to your advantage to create your own wiring arrangement according to the size of the parts you have on hand and the size of board you wish to use.
All the other components are standard and you should have little trouble fitting them into position.

If you are going to fit the completed unit into an old radio case, you should cut the board to size before soldering the parts. Fortunately we have not experienced any instability between the front end and the audio amplifier however we have provided heavy decoupling with an electrolytic across the battery. It should be remembered that motorboating may be produced if this electrolytic is removed and the battery begins to age.

If you have a 15R speaker or even a 47R speaker, these can be connected directly to the emitter lead of the third transistor and ground. The 15R resistor is removed . These types of speakers will be even more efficient in this type of circuit than the 8R variety and they should be used in preference.

Almost any NPN transistor will operate in this circuit and you can remove the audio transistors from an old transistor radio.
Even though we have said the ZN 414 IC looks exactly like a BC 547 transistor, it cannot be substituted with anything else. It contains something like 8 to 10 transistors inside the package and obviously a single transistor will not perform the same function.





FURTHER EXPERIMENTING

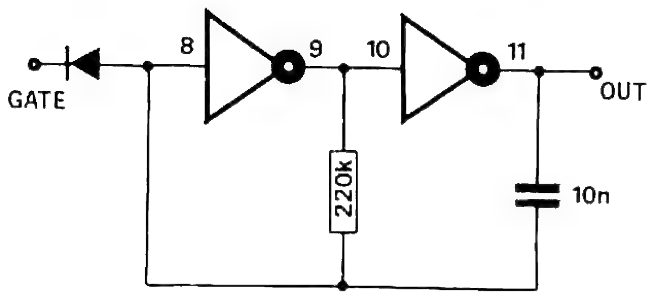
The radio is over-designed around the input to the volume control and you can eliminate the first 1n capacitor. By reducing the value of the volume control to about 2k, you can discard the two diodes as the volume control will become the voltage divider. Now the problem is to compare the output of the two designs and determine which is the louder.

You can also alter the LOAD and BIAS resistors for the three audio stages and find the optimum values for your particular transistors. Keep in mind the total current drain must be kept as low as possible for long battery life.

I hope you get as much enjoyment from this radio as I did with my 4 transistor set.

DIGI-CHASER

GATED AUDIO OSCILLATOR

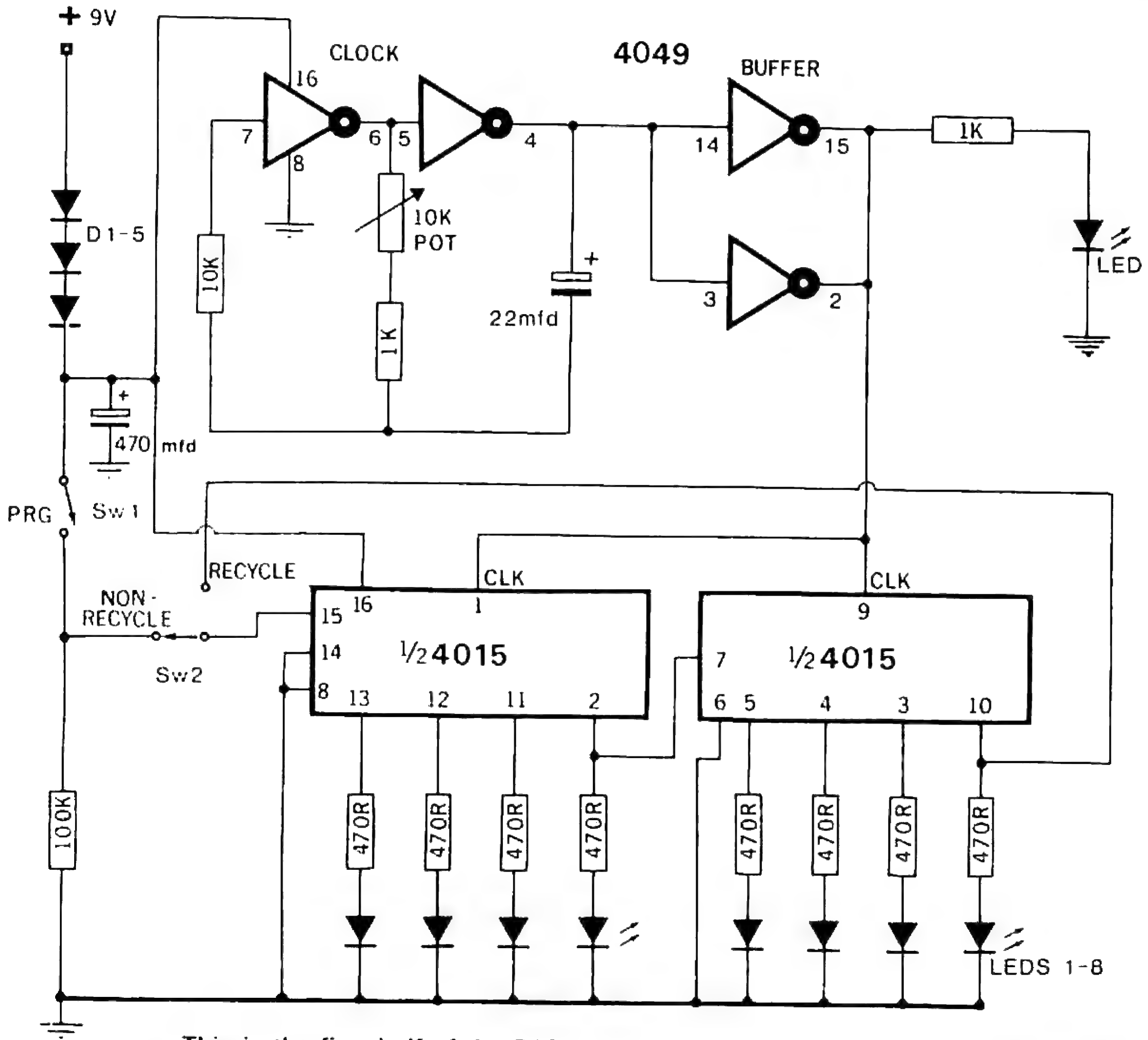


IN A NUTSHELL **15^{10} complete.**

The DIGI CHASER is constructed in 2 stages.

The first stage enables you to program 8 LEDs in any ON/OFF array. This pattern can then be re-cycled on the LED display at a speed which is adjustable via a pot.

The GATED AUDIO OSCILLATOR is designed for future experimenting. You can make a MORSE CODE output with a maximum of 128 bits by using the full count of the 4024.



This is the first half of the DIGI-CHASER circuit. It will allow 8 LEDs to be programmed. The slide switch is then shifted to re-cycle to see the pattern repeated. Some of the patterns you can create are shown in the border at the top of this article. You will be able to create many different designs and use the 10k speed control to enhance the effect.

This is the second project in our EXPERIMENTER DECK SERIES.
If you want to learn about computers, this is where you start.
This project combines two of the most impotant building blocks in computers: MEMORIES and SHIFT REGISTERS.
The operation of the circuit is very similar to a computer, only on a very small scale. It is intended to be the first stage to learning about the complex world of computers and their operation.

In fact the DIGI CHASER is so simple that it has only 5 switches. With these you will be able to write your own program, store it in the memory and then move the slide switch to recall the entire program.
This may sound complex so let's start at the beginning.

We have all seen light running around the screen at a drive-in theatre, or illuminating an eye-catching neon sign. These lights look as though they are moving around the display. It is an optical illusion. We know the lamps don't actually move at all. The way it works is simple. Every third lamp is wired to a common active line so that three actives and one earth line emerge from the sign. Each line is turned on in sequence by a rotating switch to give the running light effect. Obviously this sequence is fixed and unless one or more of the lamps burns out, the pattern will remain the same.

The readout for our project is very similar in that it has a row of LEDs, but that is where the similarity stops. We are able to make our running light change patterns. Something which the old mechanical sign could not do. We can make one light move across the row or one hole move across the display. In fact we can make any combination of lights move across the output. This idea may seem very simple but is the beginning to more complex arrangements. The moving word signs have a multiplication of this arrangement to create the necessary letters and numbers, so it is a very good foundation building block.

Although we can't call our project a computer, we can say it's a PROGRAMMABLE LIGHT CHASER - in short: a DIGI CHASER.

As with our previous EXPERIMENTER PROJECT, this DIGI CHASER is constructed in stages. This provides the maximum amount of incentive for experimenting and avoids a rush to complete it.
In addition, we have purposely mounted the components on the top of the printed circuit board so that you can see the whole wiring layout while you are experimenting.

IDENTIFYING THE PARTS.

PRG SWITCH: This puts an illuminated LED on the readout.
SLIDE SWITCH: changes the shift register from PROGRAM to RE-CYCLE.
SPEED CONTROL POT: adjusts the speed of the display via the clock.
4015: Shift Register. Feeds the 8 readouts.
4049: Clock. Feeds the Shift Register.
CLOCK LED: Indicates when the output of the clock is HIGH.
PRG LED: Indicates when a HIGH is fed into the Shift Register.
8 LEDs: The READOUT or DISPLAY.

The first stage of the DIGI CHASER uses th se components. :
★ A row of 8 LEDs which we call the DISPLAY.
★ A 4049 CLOCK
★ A 4015 SHIFT REGISTER
★ A push button called the PRG or program button.
★ A slide switch to change from recycle to non-recycle.
★ A veriable resistor to change the clock rate.
★ An LED near the program button to indicate a HIGH is being programmed into the shift register.
★ An LED near the 4049 clock to indicate the speed of the clock.
★ A row of diodes to reduce the voltage from 9v to 5v in readiness for the 2102 memory chip.

When the battery is connected, the clock oscillates at a rate which can be adjusted by the speed control and should be set to the slowest frequency for the first stage of this project.

This feeds into a shift register and every time the clock indicator LED is illuminated, the contents of one stage is shifted to the next. Depending on the layout of the printed circuit board, this will create a left moving display or right-moving display. If nothing is present in any of the register stages, the row of LEDs will be blank. This will not mean the shift register is not functioning, but only indicate that nothing is in the register.
The shift register is a positive-edge triggered device and by pressing the program button, a HIGH will be loaded into the first register. The PRG LED will illuminate to show a HIGH has been recorded.
On the next rise of the clock pulse, the HIGH will be transferred to the next stage.
If you keep your finger on the PRG button, you will pick up 2 cycles and two or more LEDs will be illuminated. If you remove your finger quickly, you will obtain only one lit LED. This LED will progress across the display on the

arrival of each clock pulse and once it reaches the end of the row, will be lost out the end of the register.
To retain an illuminated LED, the slide switch is changed to RE-CYCLE by sliding it towards the top of the board. This will create a re-cycling of any pattern you have programmed into the register. The maximum number of steps is 8 and you can create a variety of patterns qithin

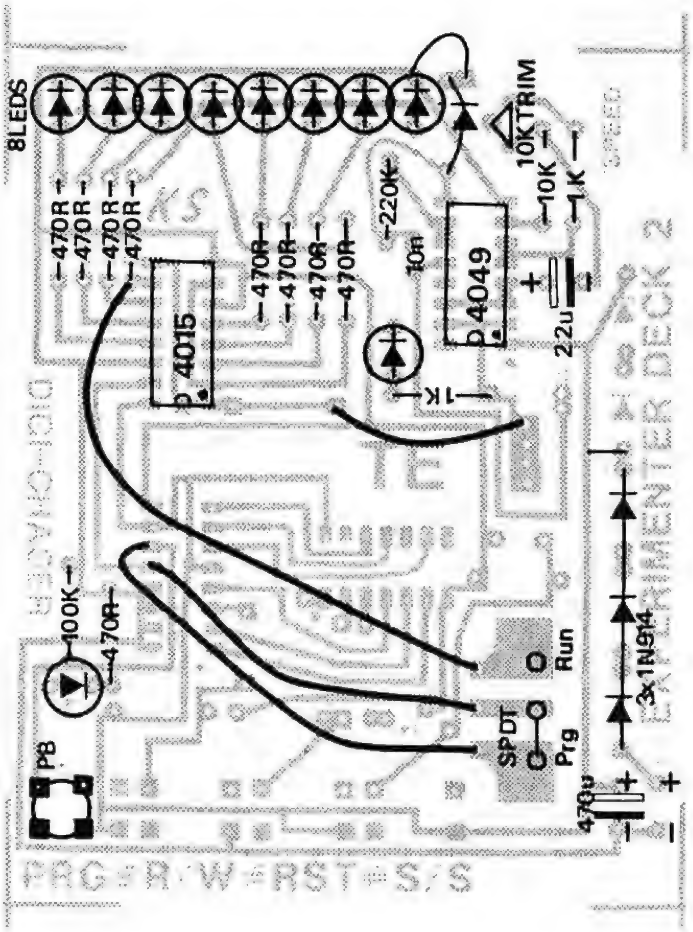
and you can create a variety of patterns within these 8 steps.

The DIGI CHASER circuit contains two separate sections which must be kept in step with each other. These are the memory and the shift register.
The memory chip will be added in the next part of the project but the full circuit will be discussed now.
We need to provide some form of synchronisation between the memory and the shift register. We need to control the rate at which the memory delivers information and we must be sure that only one pice of information is fed to the shift register at a time.

This is achieved by a control clock. It is really an oscillator producing a square wave but because of its function, we classify it as a clock.
Now the information emerging from the memory is gated into the shift register during the interval of time when the clock waveform is rising. It is important that only one memory pulse is present otherwise the shift register may respond to the HIGH, if both a high and LOW are presented.

The actual acceptance time of the shift register is relatively short compared with the waiting time for the pulse. This is important. The pulse must be delivered to the Shift Register before the clock pulse arrives and remain after it has passed. This will ensure that only one pulse is accepted.

With a clock synchronising the two blocks in the DIGI-CHASER, we need only to increase the clock rate and the program will be processed more quickly.
In any computer, a clock will control all the functions so that information can be passed from one section to another and also passed in and out of the computer without being lost.



PARTS LIST

9 - 470R
2 - 1k
1 - 10k
1 - 100k
1 - 220k

1 - 10n 100v greencap
1 - 22mfd 16v PC electro
1 - 470mfd PC electro
4 - 1N 914 diodes
1 - 10k mini trim pot
1 - 4015 shift register IC
1 - 4049 hex inverter IC
9 - 5mm Red LEDs
1 - 5mm Green LED
2 - 16 pin IC sockets
1 - slide switch SPDT
1 - push button
hook up wire
1 - battery snap
1 - DIGI CHASER PC BOARD

THE SHIFT REGISTER

The readout of the DIGI CHASER is a row of 8 LEDs. These LEDs are driven by one chip, a CD 4015 SHIFT REGISTER. This shift register has 8 outputs and to detect the state of each output, we have connected a LED. All these components can be seen on the top right hand corner of the PC board.

You can follow every connection and every printed wire from the output of the chip through the dropper resistors to the LEDs. The outputs emerge from the chip in a fairly orderly sequence but this is mere coincidence as the chip manufacturer bring out the outputs wherever it suits the wiring inside the chip. Fortunately the wiring between the chip and LED is quite neat, thanks to the beautiful layout of the PC board.

Look around this section of the board and find out how many wires or lines come into the shift register. There are only a few. These can be accounted for as follows: Pins 6, 8 and 14 go to earth and pin 16 goes to the positive rail. This leaves only pins 1 and 9 which are connected together, and pin 15, which goes to the centre of the slide switch. If we look at the pin-out diagram of the 4015, we see that these pins are marked DATA and CLOCK. This means we need TWO input signals to operate the shift register.

Our competition for guessing the number of holes in the EXPERIMENTER DECK 2 was won by Andrew Curtis, Tiffany Ave., 3192. Nobody guessed correctly but Andrew was the closest with 85 holes. If you want to know the correct number of holes, look at the PC layout at the back of this issue.

We have already mentioned the operation of the clock. It is designed to keep all the various section of the project in synchronisation. The clock signal has no part in determining a HIGH or LOW it only prepares the register to accept the input at a certain point in time. It allows the register to accept the signal which is waiting at the input pin. It "gates" or "opens and closes the input pin", each time the clock signal rises from a LOW to a HIGH.

The shift register consists of 2 completely separate 4-stage shift registers. These can be cascaded together to produce one 8-stage unit. This we have done by connecting pin 2 to pin 7. The resulting 8 outputs are connected to 8 LEDs via dropper resistors. Data is accepted at the DATA pin (pin 15) and appears at the first output (pin 13) on the rising edge of the clock pulse. The second clock pulse transfers the data to pin 12, which is the second output and this continues to each successive output after the completion of each clock pulse.

The resulting effect on the display is to see an illuminated LED run across the row of LEDs, very similar to a sequencer or light chaser. But the shift register is not limited to dislaying

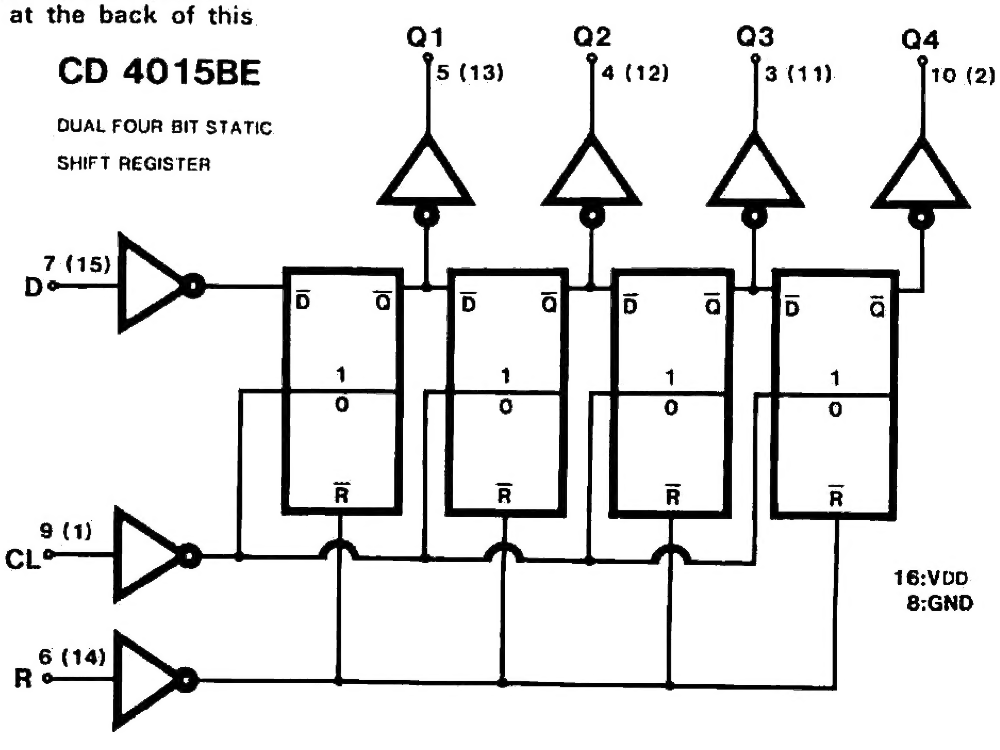
But the shift register is not limited to displaying one LED at a time. If we present a HIGH to the DATA input on the second clock pulse, the effect will be for two LEDs to become illuminated. If we now supply the DATA input with a LOW, these two LEDs will run across the row as each clock pulse is received.

SUMMARY OF FEATURES

1. Two inverting buffers can be used to produce a clock

2. Buffers can be paralleled up to provide sufficient current to drive a LED when one or two chips are also to be driven.

3. A SHIFT REGISTER shifts the information contained in the first register to the next register during the rising edge of the clock waveform.



When these illuminated LEDs reach the 8th output, they are lost from the shift register after the next clock pulse. This situation can be prevented if the output of the 8th stage is fed back to the input. This will allow 2 illuminated LEDs to circulate or cycle through the shift register indefinitely. The only way to remove the two HIGHs is to take the RESET line to positive or open the recycle path. In the DIGI CHASER, the reset line is connected permanently to ground to prevent accidental erasure of any programme and so we must open the recycle path to remove the programme.
The word programme may sound technical however it refers to any sequence of HIGHs and LOWs put into the shift register. For the first part of this project, you will only be able to write 8 steps into the register before changing the slide switch to recycle.

Any combination of HIGHs and LOWs can be set and this will circulate through the shift register. Obviously any more than 8 steps will be lost out the end of the 4015 but in the next section we include a memory to store up to 64 steps. You will then be able to produce a more interesting array or patterns.

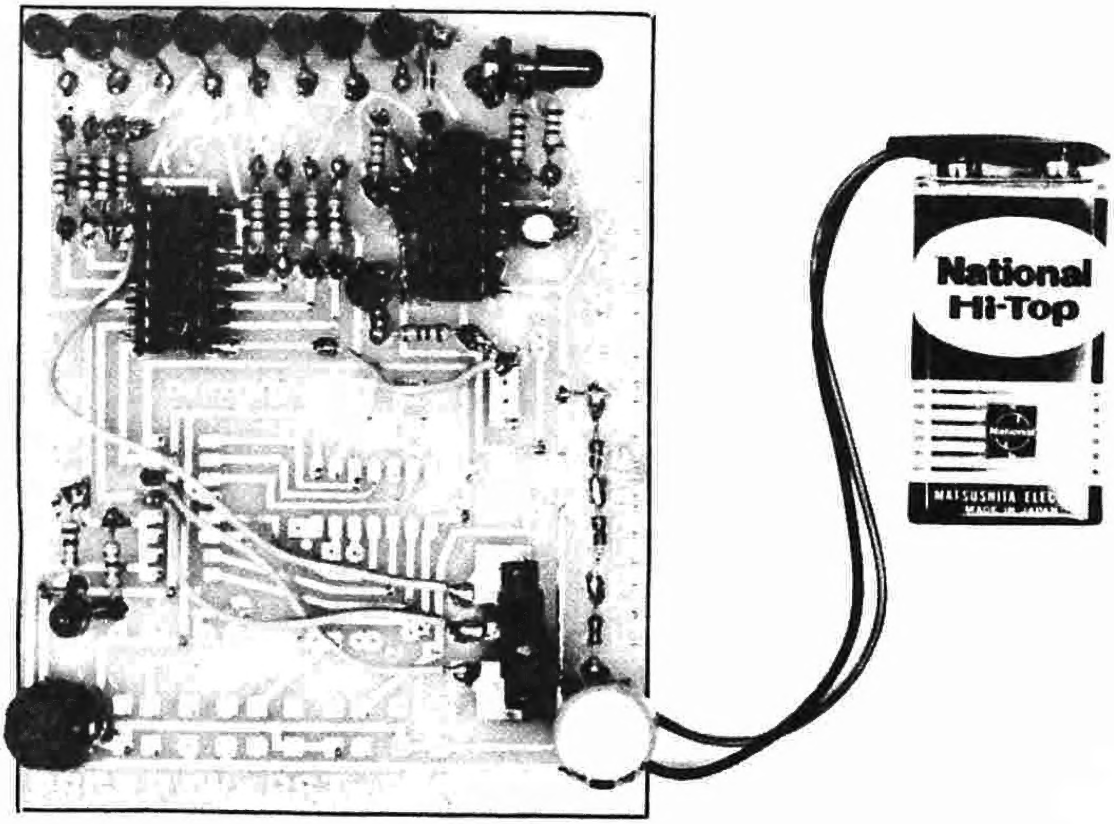
HOW THE CIRCUIT WORKS

The first section of the DIGI CHASER uses 2 ICs. A 4049 Hex inverting buffer and a 4015 dual 4-bit static shift register.
The hex buffer is used in three separate blocks:
★ A 2Hz clock
★ A buffer
★ A gated audio oscillator

The 2Hz clock is running at all times the supply is connected and drives 2 buffers connected in parallel. These provide sufficient power to illuminate a LED as well as feed the inputs of the two shift registers. The parallel buffers enable the clock line to rise high enough to clock the shift register. With only one buffer, the signal may not rise enough to be detected.

EXPERIMENTER DECK 2
Programming Instructions

STAGE 1.
1. **Switch to non-recycling.**
2. **Set oscillator to slowest speed.**
3. **Press "PRG" to illuminate first LED.**
4. **Repeat as necessary for remaining 7 LEDs.**
5. **Switch to re-cycle.**



ASSEMBLY

Don't forget, the board for this series is NOT drilled. The parts are mounted on the same side as the copper wiring. This makes the DIGI CHASER easy to follow and is ideal as a demonstration project.
The IC's are mounted in sockets. Again, the idea is to make this project as cheap as possible. By using sockets you can remove any of the chips at a later date and use them in another project. In fact any of the components can be reused, leaving only the board as the base cost.
Lay out all the parts on the work bench and make sure you have identified all the resistors correctly. The IC sockets are identified for pin 1 via a chamfer or notch in one end. The LEDs are identified by the short lead being the cathode and the diodes have a band on one end to signift the cathode. The two electrolytics have the negative lead marked. The resistors, greencap and switches can be fitted either-way-round and the mini trim pot fits directly onto the solder lands.

I prefer to commence construction with the IC sockets. This uses up many of the solder lands and gives a position reference for the other parts. They are also the most difficult items to fit onto the board and will highlight the need for a compact soldering iron. Sit them firmly on the board and solder the diagonally opposite pins. This will keep it in position while you complete the remaining pins.
The resistor leads are cut short so that the body of the resistor can be kept slightly off the board. There is no particular order for inserting the small components. You will need to use the photograph and layout diagram for the value of each component, as the board does not have an overlay.

The leads on the LED readouts can be kept as long as possible so that they stand high off the board. Firstly the leads will need to be trimmed to an equal length and the flat on the skirt of the LED positioned nearest the edge of the board. This will create a common cathode display.
Ken has cleverly used a broken LED to act as a shaft on the mini trim pot. There's a knack to soldering the LED in position to prevent the rotating wiper becoming stuck with solder. Continue with the remaining components, leaving the connection of the 4 jumper wires until last.
You will notice a few components are not essential at this stage, these being the gated audio oscillator components, the 470mfd electrolytic and the voltage dropping diodes. We have added them to the first stage to roughtly divide up the project into two equal parts. They should not cause any distraction.

Before connecting the supply, check the value of each resistor against the layout. Fit the two chips so that pin 1 corresponds to the dot or semi circle on the board. The only three components which are not identified are the two electrolytics and the gating diode. All the LEDs are identified and the slide switch can go around either way. The push button(s) can also go around either way as we are using diagonally opposite pins for the switch and its construction is such that it can be fitted in any of 4 directions when the opposite pins are used.
Connect a 9v battery. The clock LED will flash on and off. This can be increased or decreased by turning the speed control. With the slide switch in the down position, you can "write" a HIGH into the shift register and watch it travel across the display. It will disappear off the end unless the switch is changed to the up position where the shift register is converted to re-cycling. The pattern of HIGHs and LOWs will move across the display in an endless cycle.

PROGRAMMING THE DIGI CHASER

For the first stage of the DIGI CHASER you can only enter up to 8 pieces of information. This is done by pressing the PRG button when the clock LED is passing from a non-illuminated condition to an illuminated condition. To make it easy to see this part of the clock cycle, the speed control should be reduced to its minimum value. After a few attempts, you will be able to see at which precise instant the shift register records a HIGH. Try pushing the PRG button at any time during the clock cycle and you will be able to see whcih pulses are

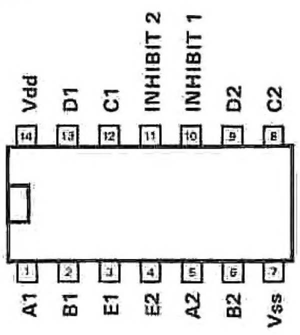
you will be able so see which pulses are detected and which pulses are not recorded. The shift register is not open at all times for recording a HIGH, but rather gated by the clock pulse when it detects the rising positive edge of the clock waveform. This corresponds to the clock LED turning on.

Quite a number of combinations can be fed into the shift register. The most impressive being a running light or a running hole. Try experimenting with different sequences and then increase the speed control to obtain the interesting effects.

The first part of the DIGI CHASER is only very elementary and you will will eager to expand the system. For this you will have to wait for the next issue. In the meantime, try producing as many different combinations as possible.

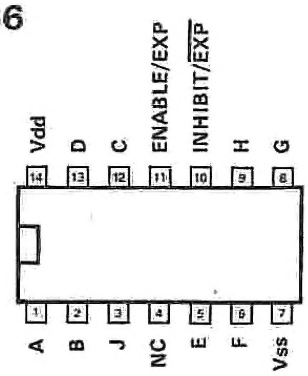
DATA

4085



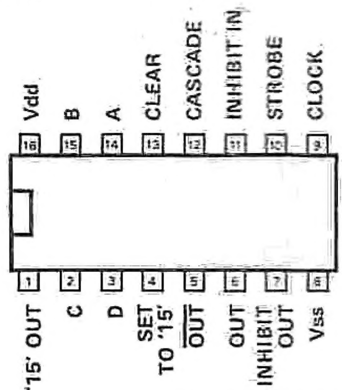
DUAL 2-WIDE 2-INPUT AND-OR-INVERT GATE

4086



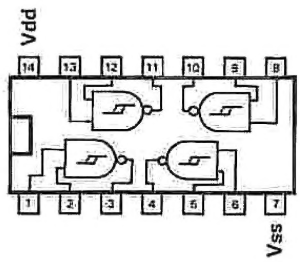
4-WIDE 2-INPUT AND-OR-INVERT GATES

4089



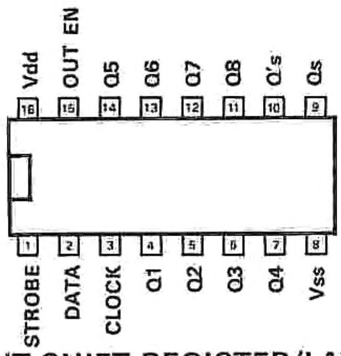
BINARY RATE MULTIPLIER

4093



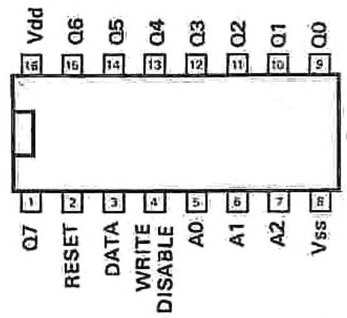
QUAD 2-INPUT NAND SCHMITT TRIGGERS

4094



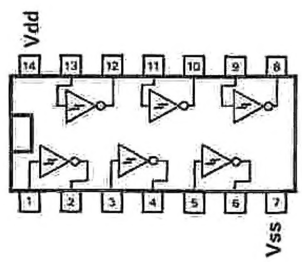
8-BIT SHIFT REGISTER/LATCH WITH 3-STATE INPUTS

4099



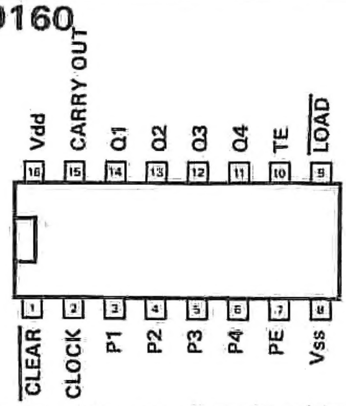
8-BIT ADDRESSABLE LATCH

40106



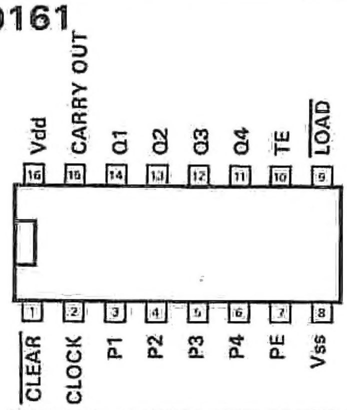
HEX SCHMITT TRIGGERS

40160



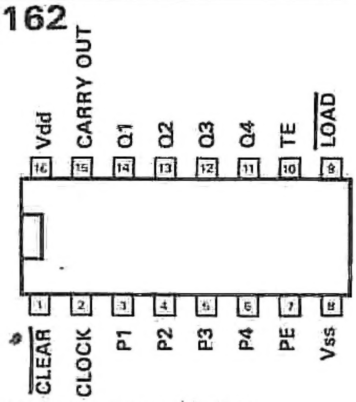
DECADE COUNTER WITH ASYNCHRONOUS CLEAR

40161



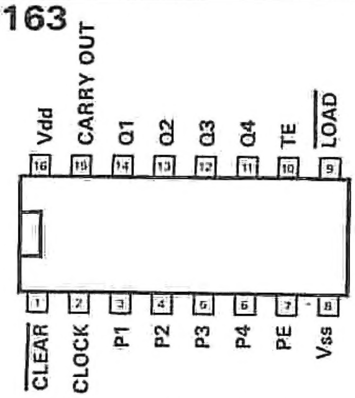
BINARY COUNTER WITH ASYNCHRONOUS CLEAR

40162



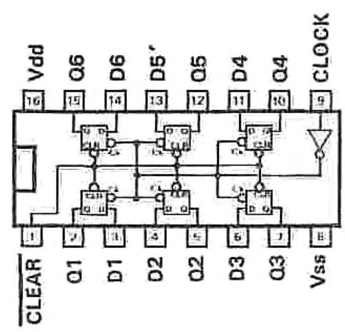
DECADE COUNTER WITH SYNCHRONOUS CLEAR

40163



BINARY COUNTER WITH SYNCHRONOUS CLEAR

40174



HEX D FLIP-FLOP

CPW

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